No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
NATIONAL RIVER CONSERVATION DIRECTORATE (NRCD)
MINISTRY OF ENVIRONMENT AND FORESTS

THE STUDY
ON
WATER QUALITY MANAGEMENT PLAN
FOR
GANGA RIVER
IN
THE REPUBLIC OF INDIA

FINAL REPORT

VOLUME IV FEASIBILITY STUDY FOR PROJECT CITIES

VOLUME IV-2 FEASIBILITY STUDY FOR KANPUR CITY
PART I SEWERAGE SCHEME

JULY 2005

TOKYO ENGINEERING CONSULTANTS CO., LTD.
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FINAL REPORT
ON
WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER
JULY 2005

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ABBREVIATIONS

AD/MM	Average Day / Max Month
ADF	Average Daily Flow
ADWF	Average Dry Weather Flow
AIWSP	Advanced Integrated Wastewater Stabilization Ponds
AL	Aerated Lagoon
AS	Activated Sludge
ASR	Aquifer Storage and Recovery System
Avg	Average
AWT	Advanced Wastewater Treatment
BOD	Biochemical Oxygen Demand
CI	Cast Iron
CMS	Cubic Meter per Second
CO_2	Carbon Dioxide
CPCB	Central Pollution Control Board
CWR	Clear Water Reservoir
DLW	Diesel Locomotive Work
DO	Dissolved Oxygen
DPR	Detailed Project Report
ES	Equalization/Storage
FAB	Fluidised Aerated Bioreactor
F/S	Feasibility Study
FSA	Future Service Area
GAP	Ganga/Gomti Action Plan
GoAP	Gomti Action Plan
GIS	Geographical Information System
gpd	Grams per day
GOI	Government of India
GOJ	Government of Japan
GWI	Ground Water Infiltration
HDR	High-Density Residential
HP	Horse Power
I/I	Infiltration/Inflow
ISC	Indian Standard Code
JICA	Japan International Cooperation Agency
JS	Jal Sansthan
KVA	Kilo Volt Ampere
LDR	Low-Density Residential
lpcd	Litres per capita per day
lpm	Litres per minute
lps	Litres per second
MC	Municipal Corporation
MDR	Medium-Density Residential
mg/l	Milligrams per Litre
ML	Million Litres
mld	Million Litres per Day
MLSS	Mixed Liquor Suspended Solids
M/P	Master Plan
MPN	Most Probable Number per 100ml
MPS	Main Sewage Pumping Station
MPS	Meter per Second
MUD	Ministry of Urban Development
MoEF	Ministry of Environment and Forests
N/A	Not Available
NBC	National Building Code
NH_3-N	Ammonia-Nitrogen
NRCD	National River Conservation Directorate
NSA	Non Sewerage Area
O&M	Operations and Maintenance
PDWF	Peak Dry Weather Flow
PFR	Project Feasibility Report
PS	Pumping Station
PSC	Pre-Stressed Concrete
RAS	Return Activated Sludge
SMF	Sankat Mochan Foundation
SPS	Sewage Pumping Station
SS	Suspended Solids
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UASB	Up flow Anaerobic Sludge Blanket
UFW	Unaccounted for Water
UPJN	Uttar Pradesh Jal Nigam
UPPCB	Uttar Pradesh Pollution Control Board
USAID	United States Agency for International Development
UV	Ultra Violet
VCP	Vitrified Clay Pipe
WAS	Waste Activated Sludge
WRF	Water Reclamation Facility
WSP	Waste Stabilization Pond
WTP	Water Treatment Plant
YAP	Yamuna Action Plan

GLOSSARY OF TERMS

Aerated Lagoons*:* Like WSPs but with mechanical aeration. Oxygen requirement mostly from aeration and hence more complicated and higher O&M costs requires less land than WSP.

Activated-Sludge Process: A biological wastewater treatment process in which a mixture of wastewater and biologically enriched sludge is aerated to facilitate aerobic decomposition by microbes.

Advance Wastewater Treatment: Treatment process designed to remove pollutants that are not adequately removed by conventional secondary treatment processes.

Aeration: The addition of air or oxygen to water or wastewater, usually by mechanical means, to increase dissolved oxygen levels and maintain aerobic conditions.

Anaerobic Digestion: Sludge stabilization process in which the organic material in biological sludge is converted to methane and carbon dioxide in an airtight reactor.

Assimilative Capacity: The ability of a water body to receive wastewater and toxic materials without deleterious effects on aquatic life or the humans who consume the water.

Average Daily Flow: The total flow past a physical point over a period of time divided by the number of days in that period.

Biochemical Oxygen Demand (BOD): A standard measure of wastewater strength that quantifies the oxygen consumed in a stated period of time, usually 5 days and at 20^{o}C.

Biological Process: The process by which the metabolic activities of bacteria and other micro organisms break down complex organic materials to simple, more stable substances.

Bio solids: Solid organic matter recovered from municipal wastewater treatment that can be beneficially used, especially as a fertilizer. *Bio solids* are solids that have been stabilized within the treatment process, whereas sludge has not.

Chlorination: The addition of chlorine to water or wastewater, usually for the purpose of disinfection.

Coliform Bacteria: Rod shaped bacteria from intestinal track of man used as an indication that pathogenic organisms may also be present.

Collection System: In wastewater, a system of conduits, generally underground pipes, that receives and conveys sanitary wastewater and/or storm water. In water supply, a system of conduits or canals used to capture a water supply and convey it to a common point.

Composting: Stabilization process relying on the aerobic decomposition of organic matter in sludge by bacteria and fungi.

Dechlorination: The partial or complete reduction of residual chlorine by any chemical or physical process.

Design Storm: The magnitude of a storm on which the design of a system and/or facility is based; usually expressed in terms of the probability of an occurrence over a period of years.

Diffused-Air Aeration: The introduction of compressed air to water by means of submerged diffusers or nozzles.

Digester*:* A tank or vessel used for sludge digestion.

Disinfection: The selective destruction of disease-causing microbes through the application of chemicals or energy.

Diurnal: A daily fluctuation in flow or composition that is of similar pattern from one 24-hour period to another.

Effluent: Partially or completely treated water or wastewater flowing out of a basin or treatment plant.

Fine-Bubble Aeration: Method of diffused aeration using fine bubbles to take advantage of their high surface areas to increase oxygen-transfer rate.

Fixed Film Process: Biological wastewater treatment process whereby the microbes responsible for conversion of the organic matter in wastewater are attached to an inert medium such as rock or plastic material. Also called *attached-growth process.*

Force Main: The pipeline through which flow is transported from a point of higher pressure to a point of lower pressure.

Friction Factor: A measure of the resistance to liquid flow that results from the wall roughness of a pipe or channel.

Gravity Thickening: A process that uses a sedimentation basin designed to operate at high solid loading rate, usually with vertical pickets mounted to revolving sludge scrapers to assist in releasing entrained water.

Grit Chamber: A settling chamber used to remove grit from organic solids through sedimentation or an air-induced spiral agitation.

Head Loss: The difference in water level between the upstream and downstream sides of a conduit or a treatment process attributed to friction losses.

Headworks: The initial structure and devices located at the receiving end of a water or wastewater treatment plant.

Infiltration: Water entering a sewer system through broken or defective sewer pipes, service connections, or manhole walls.

Influent: Water or wastewater flowing to a basin or treatment plant.

Invert: The lowest point of the internal surface of a drain, sewer, or channel at any cross section.

Land Application: The disposal of wastewater or municipal solids onto land under controlled conditions.

Lift Station: A chamber that contains pumps, valves, and electrical equipment necessary to pump water or wastewater.

Methane: A colourless, odourless combustible gas that is the principal by-product of anaerobic decomposition or organic matter in wastewater. Chemical formula is CH_4.

Mixed Liquid Suspended Solids (MLSS): Suspended solids in the mixture of wastewater and activated sludge undergoing aeration in the aeration basin.

Nitrification: Biological process in which ammonia is converted first to nitrite and then to nitrate.

Nutrient: Any substance that is assimilated by organisms to promote or facilitate their growth.

Pathogen: Highly infectious, disease-producing microbes commonly found in sanitary wastewater.

Peak Flow: Excessive flows experienced during hours of high demand; usually determined to be the highest 2-hour flow expected under any operational conditions.

Preliminary Treatment: Treatment steps including screening, grit removal, preparation, and/or flow equalization that prepare wastewater influent for further treatment.

Pump Station: (see lift station)

Primary Clarifier: Sedimentation basin that precedes secondary wastewater treatment.

Primary Treatment: Treatment steps including sedimentation and/or fine screening to produce an effluent suitable for biological treatment.

Rising Main : (see force main)

Reclaimed Wastewater: Wastewater treated to a level that allows its reuse for a beneficial purpose.

Return Activated Sludge (RAS): Settled activated sludge that is returned to mix with raw or primary settled wastewater.

Sanitary Sewer Overflow (SSO): Overloaded operating condition of a sanitary sewer that results from inflow/infiltration.

Screening: (1) A treatment process using a device with uniform openings to retain coarse solids. (2) A preliminary test method used to separate according to common characteristics.

Scum: Floatable materials found on the surface of primary and secondary clarifiers consisting of food wastes, grease, fats, paper, foam, and similar matter.

Secondary Clarifier: A clarifier following a secondary treatment process and designed for gravity removal of suspended matter.

Secondary Treatment: The treatment of wastewater through biological oxidation after primary treatment.

Sludge: Accumulated and concentrated solids generated within the wastewater treatment process that have not undergone a stabilization process.

Sludge Dewatering: The removal of a portion of the water contained in sludge by means of a filter press, centrifuge, or other mechanism.

Sludge Stabilization: A treatment process used to convert sludge to a stable product for ultimate disposal or use and to reduce pathogens to produce a less odorous product.

Suspended-Growth Process: Biological wastewater treatment process in which the microbes and substrate are maintained in suspension within the liquid.

Thickening: A procedure used to increase the solids content of sludge by removing a portion of the liquid.

Trickling Filters: Sewage passes down through a loose bed of stones, and the bacteria on the surface of the stones treats the sewage. An aerobic process in which bacteria take oxygen from the atmosphere (no external mechanical aeration). Has moving parts, which often break down.

Total Suspended Solids (TSS): The measure of particulate matter suspended in a sample of water or wastewater. After filtering a sample of a known volume, the filter is dried and weighed to determine the residue retained.

Waste Activated Sludge (WAS): Excess activated sludge that is discharged from an activated-sludge treatment process.

Wetlands Treatment: A wastewater treatment system using the aquatic root system of cattails, reeds, and similar plants to treat wastewater applied either above or below the soil surface.

Waste Stabilization Pond: Large surface area ponds that provide treatment essentially by action of sunlight, encouraging algal growth which provides the oxygen requirement for bacteria to oxidize the organic waste. Requires significant land area, but one of the few processes that is effective at treating pathogenic material. Natural process with no power/oxygen requirement. Often used to provide water of sufficient quality for irrigation, and very suited to hot, sunny climates.

UASB: Anaerobic process using blanket of bacteria to absorb polluting load. Suited to hot climates. Produces little sludge, no oxygen requirement or power requirement, but produces a poorer quality effluent than processes such as ASP. (NOTE: other anaerobic processes exist, but UASB is the most common at present).

Collection System Terminology

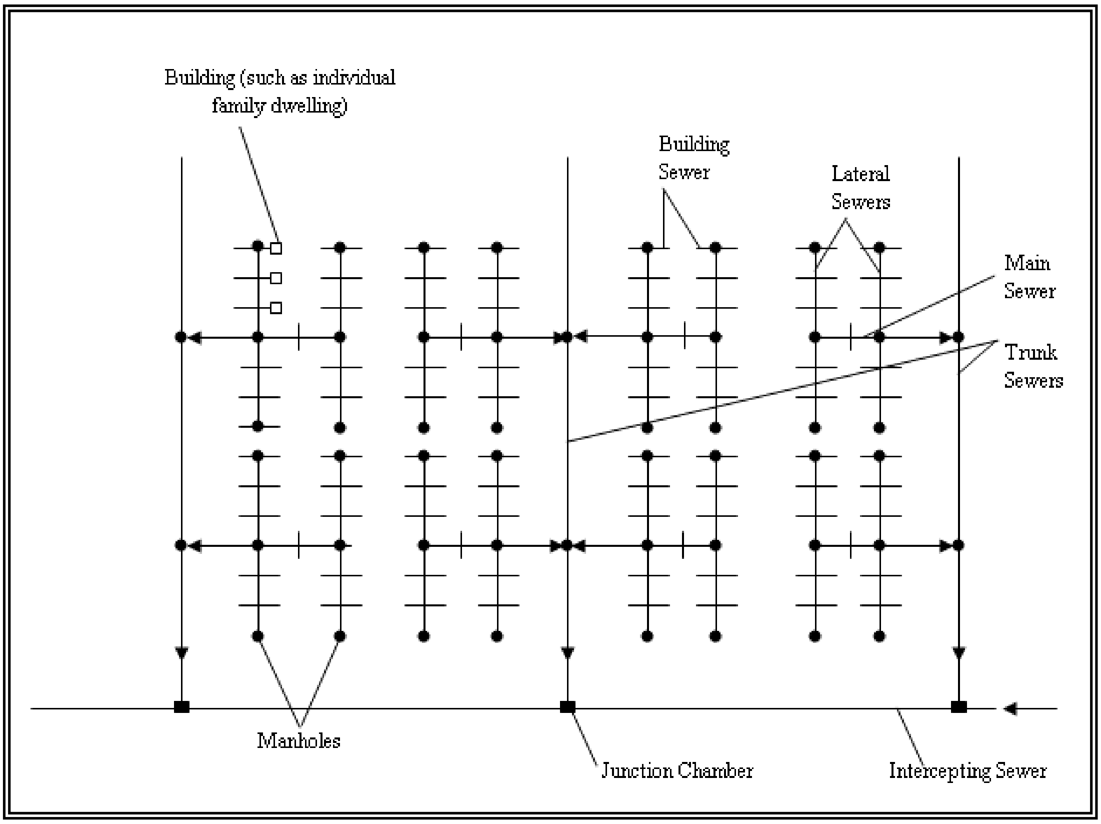
Interceptor Sewer: A sewer that receives flow from a number of other sewers or outlets for disposal or conveyance to a treatment plant.

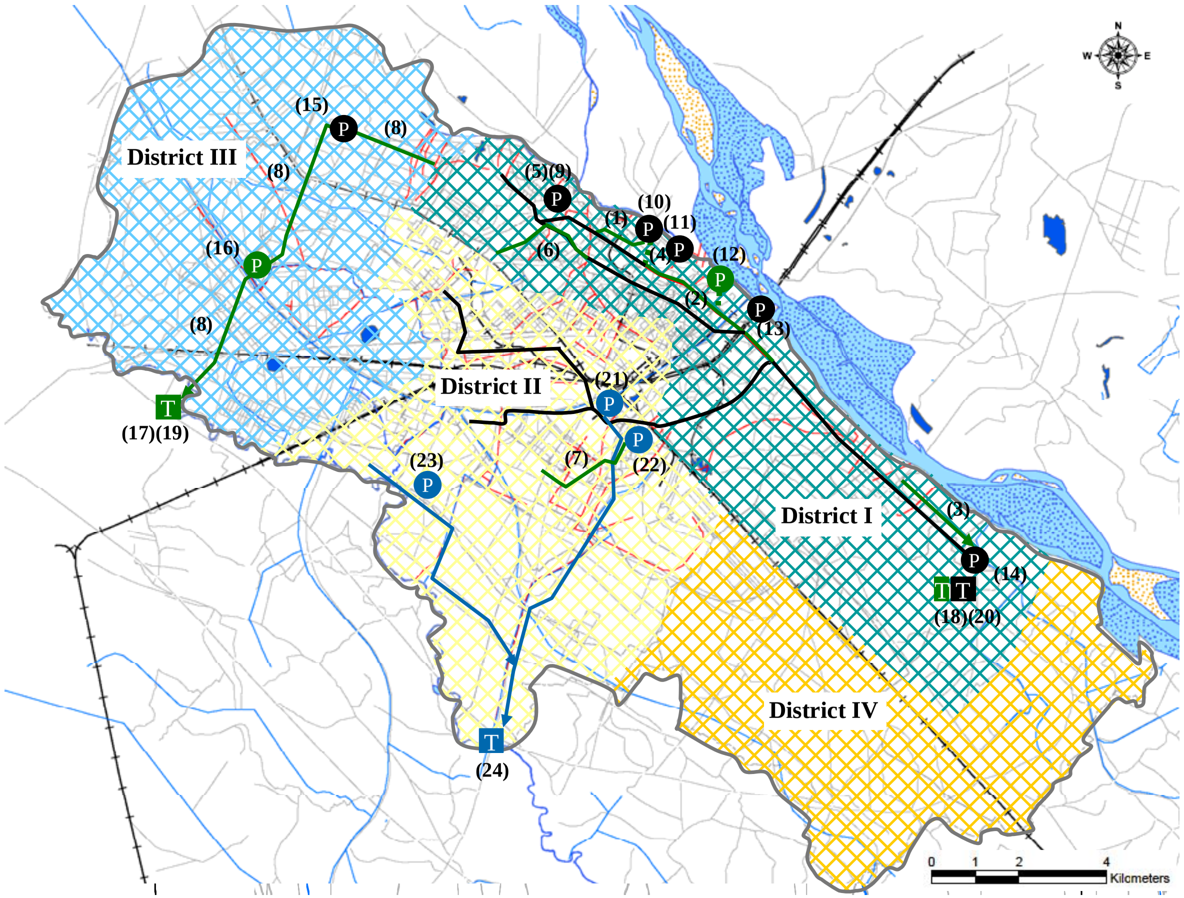
Manhole: An opening in a vessel or sewer to permit human entry. Also called *manway.*

Trunk Sewer: Trunk sewers are large sewers that are used to convey wastewater from main sewers to treatment or other disposal facilities or to large intercepting sewers.

Main Sewer: Main sewers are used to convey wastewater from one or more lateral sewers to trunk sewers or to intercepting sewers.

Lateral Sewer: Lateral sewers form the first element of a wastewater collection system and are usually in streets or special easements. They are used to collect wastewater from one or more building sewers and convey it to main sewers.





Legend

Municipal Boundary
Sewer
Rising Main
Ⓟ Pump Station
T Treatment Plant

Black : Existing Facility
Blue : Sanctioned Facility
Green : Proposed Facility

	Sewer / Rising Main	District	Status	Diameter / Length
1	Sewer from Sisamau nala to Parmat SPS	I	P	1600 mm, 1.5 km
2	Sewer from Rawatpur to Cantonment area	I	P	700-2200 mm, 9.9 km
3	Sewer in Jajmau tannery area	I	P	300-1600 mm, 8.4 km
4	Rising main of Parmat SPS	I	P	1000 mm, 1.6 km
5	Rising main of Nawabganj SPS	I	P	450 mm, 1.5 km
6	Rising main of Bagwatdas ghat SPS	I	P	400 mm, 1.2 km
7	Existing trunk sewer in District I	I	E/R	Desilting: 700-2200 mm, 9.2 km Rehab.: 700-2200 mm, 5.8 km
8	Existing trunk sewer in District II	II	E/R	Desilting: 838 mm, 1.6 km Rehab.: 838 mm, 2.4 km
9	Rising main of Lakhanpur SPS	III	P	600 mm, 0.7 km
10	Rising main of Pnki SPS	III	P	1200 mm, 0.3 km
11	Rising main of MPS at Panka STP	III	P	1400 mm, 1.5 km
12	New trunk sewer in District III	III	P	600-2000 mm, 14.3 km

	Pumping Station	District	Status	Capacity (mld)	Remarks
13	Nawabganj SPS	I	E/R	12	Peak flow
14	Parmat SPS (Existing)	I	E/R	109	
	Parmat SPS (New)	I	P	100	
15	Muirmill SPS	I	E/R	8	
16	Bhagwatdas Ghat SPS	I	P	20	
17	Guptar ghat SPS	I	E/R	10	
18	Jajmau SPS	I	E/R	154	
19	Lakhanpur SPS	III	E/R	45	
20	Panki SPS	III	P	160	
21	MPS at Panka STP	III	P	270	

	Treatment Plant	District	Status	Capacity (mld)	Remarks
22	Jajmau STP (ASP)	I	E/A	173	Average flow
23	Panka STP (UASB)	III	P	120	
	Total			293	

Existing / Sanctioned Facility

	Facility	District	Status	Remarks
24	Jajmau STP (UASB)	I	E	for industrial wastewater
25	Rakhimandi SPS	III	S	
26	Munshi Purwa SPS	III	S	
27	Ganda Nala SPS	III	S	
28	Bingawan STP (UASB)	III	S	

E: Existing
S: Sanctioned
P: Proposed
R: Rehabilitation
A: Augmentation

JAPAN INTERNATIONAL COOPERATION AGENCY
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PROJECT	LOCATION	
THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA	Kanpur City	Proposed Sewerage Facilities for Feasibility Study (Kanpur)

CHAPTER 1

INTRODUCTION

PART I SEWERAGE SCHEME

CHAPTER 1 INTRODUCTION

In response to a request from the Government of India, Japan International Cooperation Agency (JICA) has undertaken “The Study on the Water Quality Management Plan for Ganga River in the Republic of India” by formulating JICA Study Team comprising of Tokyo Engineering Consultants Co., Ltd. in association with CTI Engineering International Co., Ltd. The Study started in February 2003 and has concluded in March 2005.

The objectives of the Study are:

- To formulate the Master Plan for water quality management for Ganga River with the target year of 2030, focusing on Kanpur, Allahabad, Varanasi and Lucknow
- To carry out Feasibility Study (F/S) for the priority projects identified in the Master Plan

The Master Plan for Kanpur has been prepared by the JICA Study Team, which encompasses the basic planning framework while identifying the priority projects for F/S.

1.1 PROJECT BACKGROUND

The consultancy services and survey activities for the F/S components were to be sub- contracted to a Local Consultant. Subsequently JICA Study Team issued “Request for Proposal” on September 7, 2004 to carry out the F/S comprising engineering services and the required survey activities for the priority projects for Kanpur city. In response to the Request for Proposal, MWH India Private Limited (MWH), Mumbai submitted their Technical and Financial Offer on September 15, 2004 for the required services.

JICA Study Team, after scrutinising technical proposal of various local consultants, adjudged MWH technical proposal best and had invited MWH for the discussions on their Technical and Financial Proposals on September 23, 2004. After the detailed discussions and the financial negotiations.
Tokyo Engineering Consultants, on-behalf of JICA Study Team, entered into an agreement with MWH India Pvt. Ltd, Mumbai to carry out the Feasibility Study for Kanpur on 21st October 2004. As required by the JICA Study Team, MWH has mobilized their team swiftly, for preparation of Feasibility Study Report for Kanpur.

The scope of the F/S assignment of Kanpur includes engineering services along with the required survey activities i.e. topographical survey and geo-technical survey.

The scope of the F/S includes:

- Review/ collection of existing documents,
- Review of Master Planning framework and proposals,
- Assessing capacities of existing facilities,
- Evaluation of design alternatives and determination of planning framework for F/S,
- Detailed field survey for the F/S covering Topographical survey and soil investigation,
- Preliminary design and cost estimation for priority projects of sewerage scheme,
- Implementation planning and procurement of the machinery and material,
- Organisation, operation & maintenance and human resource development plan,
- Environmental Impact Assessment, and
- Overall evaluation of the project for F/S

1.2 DELIVERABLES SUBMITTED

As per agreement, MWH was to prepare and submit following reports during the assignment.

Table 1.1 List of Deliverables

Sr.	Deliverable	Details
1.	Inception Report	Initial understanding of the project and detailed work plan based on the proposal
2.	Progress Report	Brief explanation of the study progress
3.	Survey Report	All the survey results as specified in the technical specifications for the survey work
4.	Draft Feasibility Report	All the study results
5.	Final Feasibility Report	All the study results including the comments of JICA Study Team on the draft report

MWH mobilised their team of experts, headed by Team Leader, at site to start the work and submitted Inception Report, Progress report, Survey report and Draft Feasibility Report as per agreed schedule.

1.3 ABOUT THIS REPORT

This report, the Volume IV-2, Part-I Sewerage Scheme of Kanpur, titled “ Final Feasibility Report”, under series of deliverables, provides details of scope of work, and the corresponding work carried out, covering review of collected data and Master Plan.

This report is divided into twelve sections describing the various components of this feasibility study. The planning basis adopted for the feasibility study is explained in the second section; similarly the design basis is presented in Section 3.

The preliminary design of the sewerage network is presented in section 4. For the ease of understanding the design sections of the report are structured district wise. Similarly, the preliminary design of the pumping stations and sewage treatment plant are discussed in Section 5 and 6, respectively.

The rehabilitation of the sewers is discussed in Section 7, while the augmentation/rehabilitation of old sewage pumping stations is discussed in Section 8. Similarly, the rehabilitation of the exiting treatment plant is described in Section 9.

The existing state of the institutions involved and the capacity building strategy of these institutions are discussed in another volume in part IV of the F/S Report titled as Institutional Development Programme.

As a part of the study the impact of the feasibility components on the environment has been assessed and the same is presented in Section 10 of the report.

The implementation strategy for the feasibility components are discussed in Section 11, while the abstract cost estimates are presented as concluding section of the report in Section 12.

CHAPTER 2

PLANNING BASIS

CHAPTER 2 PLANNING BASIS

As a first step of the feasibility study MWH collected various documents, from the JICA Study Team and reviewed all these documents to understand the existing situation. Based on this review and subsequent discussion with the concerned organisations, a planning basis has been formulated for the F/S. The formulated planning basis along with the understanding of the city and components of the F/S is presented in this section of the report.

2.1 REVIEW / COLLECTION OF EXISTING DOCUMENTS

The various documents, listed below, have been collected from the JICA Study Team along with the Master Plan, prepared by JICA Study Team.

- Influent and effluent wastewater characteristics for Jajmau treatment plants
- UPJN Preliminary Estimate for water supply for east district of Kanpur Nagar through Ganga Barrage, August 2003.
- UPJN Preliminary feasibility report for 1600 mld water supply scheme through Ganga Barrage
- UPJN Detailed project report for laying trunk sewer along COD nala
- Rapid environmental impact assessment report, 200 mld UASB STP, Kanpur South, may 16,2001, under Indo-Dutch assistance.
- UPJN addendum to detailed project report Intermediate sewage pumping station at Munshipurwa 1999-2000
- UPJN addendum to detailed project report Intermediate sewage pumping station at Rakhimandi
- UPJN Kanpur Sewerage Reorganisation Master Plan 1979-2001
- Census data 2001 for wards administered by Kanpur Municipal Corporation
- UPJN feasibility report for integrated pollution abatement & river management for Ganga basin at Kanpur, March 2003.
- Jal Sansthan drawings of existing trunk, lateral and branch sewers

2.2 GENERAL ENVIRONMENT

The general environment of Kanpur city and the Kanpur district is presented in this subsection.

2.2.1 Topography

The topography of Kanpur city is generally flat and a ridgeline divides the town in two parts, one sloping towards river Ganga and the other towards river Pandu in the south.

2.2.2 Geology

Geologically the district exposes quaternary sediments differentiated into older alluvium consisting of oxidized, brown, yellow and khaki coloured sediments. Geomorphologically, the terrain of Kanpur is differentiated into lowland and upland. The upland lies in Yamuna-Ganga interfluve with elevations of 125 to 141m above Mean Sea Level (MSL). The lowland with elevations of 110 to 135m above MSL consists of older flood plain (terraces T1 and T2) and active flood plain.

The soils of this zone are alluvial, highly productive and constitute one of the most fertile belts of India. Salt affected soils (user lands) are found in patches in Kanpur with medium to strong salinity and very high alkaline soil reaction. They have a poor nutrient status i.e. they are low in organic matter, low to medium in available phosphorous (P) and potash (K) and critical in zinc and copper.

2.2.3 Climate

Climate of Kanpur is tropical in nature and the city encounters seasonal variation of climate throughout the year with high temperatures during summer, cold weather during winter and sufficient rain during monsoon.

Calm wind conditions prevail during winter between November-February with an average wind speed of 5 to 10 kmph from N/NW direction during this period. Occasional dust storms prevail with high wind speeds in summer. Winds are relatively stronger during monsoon from S/SW with a velocity of around 10 to 30 kmph.

The hottest months are May and June with mercury levels touching 40 °C to 45 °C. Usually summers are dry with 35 to 70% relative humidity. Temperature falls to 6.5 to 10^{o}C during December and January. There are instances of temperatures reaching as low as 1^{o}C during peak winter and maximum temperature as high as 48^{o}C during peak summer.

Onset of monsoon starts during late June and continues till October. The annual rainfall is in the range of 420 to 1300 mm per year with average being 821 mm per annum. Sporadic rains may be seen during winter from northwest monsoon.

2.2.4 Water Resources

The main source of surface water in Kanpur is river Ganga and river Pandu. The water flow in the Ganga varies between a mean minimum of 72.6 m^3/s and a mean maximum of 8.860 m^3/s. After tapping water for the Upper and Lower Ganga Canals, minimum water flow of 6m^3/s is maintained in the Ganga near Kanpur.

At Kanpur the Ganga river course has shifted from the right bank to the left bank from 1920. Therefore, a channel from the river course to Bhaironghat was made for the main water supply intake of Kanpur.

The quality of Ganga water intake point has been satisfactory between the years 1997 and 2001 with DO ranging from 7.5 mg/l to 9.1 mg/l.

The Pandu river is meandering river and it flows into Ganga at a point of 25 km downstream of Kanpur. The highest water level in the river is 119.6 m above MSL and the mean water level is 114.5 m above MSL. The Pandu river is polluted by the discharge of fly ash from the power station in Panki causing grey colour and high turbidity, and by the discharge of wastewater from Kanpur via the COD nala, the Ganda nala and the Halwa khanda nala.

The main causes of pollution of river Ganga and Pandu are

- Discharge of the city’s untreated sewage into the river through different drains and nalas
- Discharge of industrial wastewater

2.3 PROJECT AREA

Kanpur is the largest of the five major cities in Uttar Pradesh and its municipal limits have grown from 21.45 sq. km from 1959 to 261.59 sq.km in the year 1991. Kanpur city also accommodates number of industries, especially it has major clusters of Tanneries and Textiles.

Kanpur is geographically located at 26^{o} 28’ East longitude and 80^{o}12’ North latitude at a distance of 89 km south west from Lucknow, 435 km south east from Delhi, 192 km north west from Allahabad and 1,007 km north west from Kolkatta. The general topography of the city is flat. The historical Grand Trunk road connecting Kolkatta and Delhi bisects the town forming a ridgeline of reduced level of about 126.80 m. The area lying to the north of this road slopes towards River Ganga and that in the south towards River Pandu.

The sewerage system in Kanpur was first laid in the year 1904 for serving the civil line area. Further this system was extended to cover other parts of the city by providing trunk, main and branch sewers. Due to the growth of the city these facilities turn out to be inadequate to serve the demands of the city's growth, which forced the Kanpur Development Authority to formulate and implement a sewerage reorganisation plan. However, the Central Pollution Control Board's, 1984, report on Pollution of the River Ganga found that the pollution level in River Ganga was alarming and needs immediate attention.

To check the increasing pollution of River Ganga, Ganga Action Plan – Phase I (GAP- I) was launched in the year 1985-86. The main aim of GAP- I was abatement of pollution of the River Ganga through interception, diversion and treatment of about 160 mld of municipal sewage. The various works executed under the GAP- I are

- Cleaning of trunk and main sewers
- Interception and diversion of 16 nalas
- Construction of 160 mld capacity main pumping station at Jajmau, Kanpur
- 5 mld Treatment Plant under Indo – Dutch Assistance
- 36 mld UASB combined effluent treatment plant for tannery wastewater along with tapping of 4 nalas of Jajmau area under Indo Dutch Assistance
- 130 mld domestic Sewage Treatment Plant

In total GAP –I was to treat 170 mld, which is around 47 % of the total sewage generation in the city. In order to treat the rest of the sewage Ganga Action Plan – Phase II was proposed under the Indo – Dutch bilateral agreement and the major works of this second phase include:

- Interception and diversion of Sisamau nala, carrying 120 mld domestic wastewater, discharging directly to River Ganga and other 3 nalas flowing in southern part of Kanpur city and discharging to River Pandu, which ultimately meets River Ganga about 25 km down stream of Kanpur.
- Relieving sewers of about 8 kms
- Two intermediate sewage pumping stations at Munshipurwa and Rakhimandi to pump about 170 mld wastewater
- Construction of 200 mld UASB sewage treatment plant

UPJN is responsible for pollution prevention and planning capital projects for sewerage. UPJN also operates and maintains large pumping stations and the treatment plant. Jal Sansthan is responsible for maintenance of trunk sewers, lateral sewers and collection of revenue from house connections.

The execution of GAP – II works will significantly reduce the, present, pollution in River Ganga. However, the city experiences an exponential growth. Furthermore, the feasibility report for pollution abatement and river basin management for Ganga basin at Kanpur reveals that the city's population is projected to triple, from 2.5 million in 2001 to 7.3 million by 2030. To cater to the needs of this growth a project "Integrated Pollution Abatement and River Basin Management for Ganga Basin" aided by Government of Japan was conceived.

As stated earlier, the scope of this study is limited to the improvement in the sewerage system in the city of Kanpur.

2.4 POPULATION AND POPULATION PROJECTIONS

The infrastructure demand of a city is determined by the strategic and social consideration but often fallen short of the demands of the expanding city. To uphold such an eventuality, it is necessary to estimate the population of the city in the future.

Population projection forms an important part in infrastructure planning, which essentially makes provision of infrastructure in the city. JICA Study Team has carried out a detail ward-wise population projection. The population projection adopted in the Master Plan was reviewed for adoption of the same in the feasibility report. The sewerage district wise projected population, adopted from the Master Plan is presented in Table 2.1.

Table 2.1 District Wise Population Projections

	Year of 2003	**Year of 2015**	**Tear of 2030**
District I (City Central)	694,517	802,336	869,853
District I (City East)	310,349	461,718	585,168
District II (City Central)	843,469	1,072,781	1,172,659
District II (South)	547,771	934,330	1,172,711
District III (West)	335,790	801,640	1,283,484
District IV (East)	87,931	269,226	545,206
Total	2,819,827	4,342,031	5,629,081

2.5 EXISTING WATER SUPPLY SCHEMES

As per the JICA Master Plan the estimated water production from all sources from Kanpur in the year 2002 was 502 mld. This water is produced to serve a population, projected for the year 2002 based on 2001 Census Data, of about 2,756,865, thus the per capita production of water (Table 2.2) workout to be 140 lpcd.

Table 2.2 Estimated Per Capita Water Consumption

Population served	**2,756,865 (in 2002)**
Production capacity per capita*	182 lpcd
Less leakage losses estimated at 30%*	140 lpcd

Source: JICA Study Team

However, the CPHEEO Manual on Water Supply and Treatment, published by the Ministry of Urban Development and Poverty Alleviation, Government of India, recommends the values presented in Table 2.3, for planning municipal water supply system for domestic and non-domestic purposes:

Table 2.3 Guideline Values for Future Per Capita Water Supply

Sr.	Classification of towns/cities	Recommended maximum net per capita water supply (lpcd)
1	Towns provided with piped water supply but without sewerage system	70
2	Cities provided with piped water supply where sewerage system is existing or contemplated	135
3	Metropolitan and mega cities provided with piped water supply where sewerage system is existing or contemplated	150

Thus the production figures reported by UPJN and the present estimated per capita consumption is approximately 140 lpcd, which is slightly lower than 150 lpcd proposed by CPHEEO.

On the other hand the Master Plan prepared by JICA study Team has adopted the following values for domestic water consumption (including allowance for commercial/institutional (C/I) and minor industries estimated by UPJN):

2003: 140 lpcd + 30% UFW allowance = 182 lpcd
2015: 145 lpcd + 20% UFW allowance = 174 lpcd
2030: 150 lpcd + 15% UFW allowance = 172.5 lpcd

After detail discussion it was decided to adopt the provisions of JICA Master Plan for ascertaining the feasibility of the various proposed schemes.

2.6 EXISTING STORM WATER DRAINAGE SYSTEM

In total, as per UPJN, there are around twenty-three nalas in Kanpur city. The quantity of storm water/wastewater flowing in these nalas, measured by UPJN in 1997, is presented in Table 2.4.

Table 2.4 Flows in Existing Nala

Sr.	Name of the Nala	Quantity (mld)
1	Jageshwar Nala	3.88
2	Jewra Nala	1.46
3	Ranighat Nala	1.42
4	Tafco Nala	0.42
5	Parmat ghat Nala	0.49
6	Muir Mill Nala	4.54
7	Police Line Nala	0.40
8	Jail Nala	0.48
9	Golf Club Nala I	0.08
10	Golf Club Nala II	0.47
11	Kesa Colony Nala	1.71
12	Roadways Colony Nala	0.10
13	Kheora Nala	0.19
14	Nawabganj Nala	4.34
15	Sisamau Nala	138.33
16	Guptar ghat Nala	13.74
17	Dubka Nala	-
18	Buriahghat Nala	-
19	Wazidpur Nala	-
20	Bangalighat Nala	-
21	Halwa Khanda Nala	2.50
22	COD Nala	3.84
23	Ganda Nala	56.00
	Total Flow	213.25

Among these nalas, Tafco nala, Parma ghat nala, Police line nala and Jail nala are intercepted under the GAP-I. Similarly, under the GAP-II, Sisamau nala, the largest nala in Kanpur city, presently carrying a flow of around 138 mld will be diverted for treatment. Out of 138 mld, 80-100 mld will be tapped upstream and diverted to Bingawan STP. The remaining 30-50 mld will be tapped down stream at Parmat pumping station and diverted to Jajmau STP. Thus this flow from Sisamau nala has to be considered while finalizing the capacity of the Parmat pumping station.

2.7 EXISTING SEWAGE GENERATION

As stated earlier, the city of Kanpur can be divided into two parts sloping towards Ganga and Pandu rivers respectively. The city sewerage network laid in the year 1904 is being administered under five different zones. The total amount of wastewater measured in drains and at the STPs in 1997 was about 370 mld of which 160 mld was intercepted under GAP-I. At present, average inflow to the treatment plants is 63 mld, only 17% of the total wastewater generated.

The major zone of sewerage system 'City Drainage District' with its underground sewerage system covers around 15 lakhs population and generates 260 mld of wastewater with its out-fall into river Ganga at Jajmau. In the 'South Drainage District' only some pockets are covered under the sewerage system and rest is disposed into open nalas. The industrial effluent from Panki area meets the river Pandu separately through industrial drain. A new sewage treatment plant has been proposed under GAP-II.

The 'West Drainage District' has no sewerage facilities and the wastewater flows in to Pandu river through open nalas. The 'East Drainage District', which is primarily comprises of developing areas has also no sewerage network.

2.7.1 Sewage Generation

The JICA Master Plan reveals that the per capita sewage generated is calculated using the proposed per capita water supply rates as basis and the same is presented in Table 2.5.

Table 2.5 Per Capita Wastewater Generation Rates

	2003	2015	2030
Per capita water consumption (lpcd)	182	174	172.5
Return factor	0.70	0.75	0.80
Per capita wastewater discharge (lpcd)	127	131	138
+infiltration allowance (10%)	140	144 (say 145)	152 (say 155)

Source : JICA Study Team

The Master Plan estimates the return ratio as 0.7, by comparing total water production to measured wastewater flows. It also states that water distribution will be improved to serve a larger percentage of the population. In parallel with water supply improvements, sewerage coverage will be extended to more households and hence it is expected that a higher percentage of the population will be able to use flush toilets. Therefore the return factor will increase gradually from 0.7 to 0.8 to reflect larger amounts of wastewater from improved sanitation facilities and water supply conditions. This is a reasonable justification, thus the return factor and per capita sewage generation presented in Table 2.5, is adopted in the F/S.

2.8 PRIORITY PROJECTS (COMPONENT AND DISTRICT WISE)

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 for a design horizon of 2030 for Kanpur city. Another important focus of the JICA Study Team is to identify priority projects to undertake the Feasibility Study. The methodology of the study has been to determine the least cost approach in meeting Kanpur city’s sewerage and pollution control needs. This involves the consideration of existing infrastructure and proposal by UPJN for GAP-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 River Ganga and appointed MWH for carrying out the F/S of the same. The description of the various, district wise, components of the F/S are presented in Table 2.6.

Table 2.6 Components of Feasibility Study

Sewage District	Component	Description	Refer Section
District I	Sewer (Old)	Inspection of existing main trunk sewer for cleaning and rehabilitation planning. (replacement)	Section 7
	Sewer (New)	Installation of new domestic lateral sewers in tannery industrial area	Section 4
	Rehabilitation	Investigation for rehabilitation of old sewers	Section 7
	Pumping station (New)	Ascertain the feasibility of constructing a pumping station at Bhagwatdas ghat nala	Section 5
	Pumping station (Old)	Physical condition and capacity of mechanical equipment, rising main and sump structure and identify repair for Parmat PS, Nawab ganj PS, Muir Mill PS, Guptar ghat PS, and CSPS at Jajmau	Section 8
	STP (Old)	Physical condition and capacity of mechanical, electrical equipment, and process units, and identify repair or replacement-augment to 173 mld (average) in the year 2015	Section 9
District II	Rehabilitation	Investigation for rehabilitation	Section 7
District III	Sewer (New)	Field survey to confirm alignment and invert levels of existing pipes that needed to be crossed. Determine the feasibility of installing pipes or develop a plan for installation in another alignment.	Section 4
	Pumping station (New)	Construct a pumping station at Panki and a main pumping station at Panka STP site	Section 5
	Pumping station (Old)	Investigation and strategy for rehabilitation of Lakhanpur pumping station	Section 8
	STP (New)	Determine the feasibility of constructing a proposed Panka Bahadur Nagar S TP	Section 6

CHAPTER 3

DESIGN BASIS

CHAPTER 3 DESIGN BASIS

3.1 INTRODUCTION

MWH has received and studied the Sewerage Master Plan of Kanpur city, which is prepared by JICA Study Team. MWH has also studied and reviewed PFRs and DPRs prepared by various agencies in Kanpur, which are relevant to this project. A list of reports prepared by UPJN, KNN, KJS, and the JICA Study Team, which were collected, studied and reviewed by MWH and the results of the review, is presented in Section 2.

MWH has specific comments and suggestions for further improvements in the design of specific project components, which are presented in the relevant sections of this report. The details on design basis developed by MWH for assessing the feasibility of the various components are presented in this section. The design basis has been developed based on the current practices and past performance of the relevant components in the region, guidelines provided in Manual on Sewerage and Sewage Treatment Plants prepared by CPHEEO and the guidelines prepared by National River Conservation Directorate (NRCD)

3.2 DESIGN YEARS

In the Master Plan, design years for various schemes, are considered as per the agreement between Govt. of India and the Govt. of Japan. The Sewerage Master Plan has been prepared for the year 2030 with phased implementation occurring in 5-year intervals.
As stated earlier, Master Plan has identified a set of priority projects, which are proposed to be executed within five years after the adoption of Master Plan. Following design years have been adopted in line with the agreement between the two Governments and the provisions in Master Plan.

- For all gravity sewer lines, the design year adopted is year 2030.
- For all pumping station, civil structures are designed to satisfy the requirements of year 2030 whereas the installation of electrical, mechanical, instrumentation, automation and rising mains are designed for their requirements of year 2015.
- For all sewage treatment plants, civil structures, mechanical, electrical, instrumentation, automation works are designed for year 2015 whereas land shall be acquired for the capacities to be designed for year 2030.

3.3 DESIGN BASIS FOR SEWERAGE NETWORK

The design basis of sewerage network adopted in this Feasibility Study is described in this section.

3.3.1 Hydraulics of Sewers

For design purposes, the flow of sewage in pipes is presumed to be steady and uniform flow. The most popular equation for calculating the velocity and head loss for flow conditions in gravity sewers is Manning formula, which is used in this feasibility study for designs of gravity sewers.

$$V = \frac{1}{n} \text{ x } R^{2/3} \text{ x } S^{1/2}$$

$Q = A \text{ x } V$

Where
V = Velocity, m/s
n = Manning's coefficient of roughness of the pipe
(0.013 for design purpose, 0.015 for old sewers for RCC pipes)
R = Hydraulic radius of pipe, m
S = Slope of the energy gradient line

Q = Flow rate, m^3/s
A = Cross sectional area, m^2

(1) Peak Factors

Based on the recommended values of peak factor as per CPHEEO's Manual on Sewerage and Sewage Treatment, the peak factors adopted for contributory populations of drainage area are given in Table:3-1. Depending on the contributory population, the peak factor changes - it being higher for less population and low for high population.

Table 3.1 Peak Factors Considered for Sewerage Design

Contributory Population	Peak Factor as per CPHEEO Manual
Up to 20,000	3.00
20,000 - 50,000	2.50
50,000 - 750,000	2.25
Above 750,000	2.00

(2) Depth of Flow

The sewerage system for the ultimate design year has been designed to utilise 80% of the full bore of the pipe at peak flows. It is proposed to select an optimum size of sewer considering that the pipes will utilise less than 80% of the full bore in the design year and will also achieve self cleaning in early years. This will result in cost savings and also help in achieving the reduced operation and maintenance.

(3) Velocities

It is necessary to size the sewer to have adequate capacity to carry peak flow at the end of design period, so as to avoid steeper gradients and deeper excavations. It is desirable to design sewers for higher velocities wherever possible. This is done on the assumption that although silting might occur at minimum flow, the silt would be flushed out during the peak flows. However, the problem of silting may have to be faced in the early years, where the depth of flow during early years is only a small fraction of the full depth. Similarly, upper reaches of laterals pose a problem as they flow only partly full even at the ultimate design flow because of the necessity of adopting the prescribed minimum size of sewer. In such situations, flushing arrangements may be provided in the initial years. The sewerage system has been designed for a minimum velocity of 0.8 m/sec. for design flow i.e. peak flow at design horizon.

(4) Sizing of Pipes and Slopes

The size of pipes and slope is calculated for contributory population based on the contributory area of the individual administrative wards and the projected population of the respective Administrative Wards for the design horizon year 2030. The pipe diameter is selected by considering (d/D) ratio of 0.8 (80% bore utilisation). The corresponding flattest slope is provided so as to achieve the minimum required self cleaning velocity with an aim to minimise sewer depth thus ensuring reduced cost. In cases where (i) the topography does not permit to have the calculated gradient for full bore utilisation and/or (ii) the proposed sewer is to be connected to an existing line, which is at a shallow depth, a higher size pipe is selected to match the crown of connecting sewers.

(5) Minimum Pipe Size

The interceptor sewers and secondary sewers have been designed considering the minimum size of sewer as 500 mm and 300 mm respectively.

(6) Minimum Depth of Cover

The minimum depth of cover of 1.5m has been considered. The actual depth of cover may vary, as most of the sewers are planned on proposed roads. While finalising the depth of initial manhole, care shall be taken so that the secondary sewer lines, when laid, shall be connected to these priority main intercepting sewers.

(7) Maximum Depth of Sewer

The sewerage system has been designed such that the maximum cover of sewer will be about 10 meters below ground level. In many areas construction of sewers below 10 meters becomes very difficult. This shall increase the cost of construction and maintenance. Hence as per the prevailing practice it is proposed to lift the sewage by the proposition of a Sewage Pumping Station once the sewer depth reaches around 10 meters.

3.3.2 Sewer Appurtenances

(1) Manholes

Standard circular manholes have been recommended for pipe diameter up to 1200-mm. However, rectangular manholes should be provided for shallow depths. General arrangement drawing is presented in drawing No KAN-TYP-1 “Typical Details of Ordinary Manholes and Vent Shafts.

(2) Scraper Manholes

For sewers of diameter 600 mm and above, scraper manholes shall be provided at major junctions and at an interval of every 150 m. Scraper manhole openings will range from 900 to 1200 mm size to permit lowering of sewer cleaning equipment. It is very important to construct scraper manholes as the sewers are designed to serve for long term, which shall run with quite less flow during the initial years resulting into silting.

(3) Drop Arrangement

The drop arrangement consists of a pipe that drops the invert of the incoming sewer to that of the main sewer in the manhole. The diameter of the drop pipe should be at least as large as the incoming pipe. Theoretically drop arrangements are provided where the drop of an incoming sewer in manhole exceeds 600 mm. Drop arrangements are provided in manhole for the following reasons:

To convey the sewage to bottom of the manhole without splashing
To minimise the scouring action of the sewage falling from a height on the cement concrete floor of the manhole
For the safety of the personnel who enter the manhole

(4) Receiving Manhole at Pressure line Discharge

A 2 m x 2 m receiving sump with the provision of PVC splash pad is proposed for chamber-type manhole into which pressure line is discharged prior to joining the gravity sewer.

(5) Vent Shafts

Ventilation shafts will be provided at the head end of every sewer and along the sewers at about 150-m interval as well as at junctions. General arrangement drawing for the typical Vent Shaft is presented in drawing No KAN-TYP-1 “Typical Details of Ordinary Manholes and Vent Shafts.

(6) Pipe Selection

The materials used extensively for sewerage in most Indian cities are glazed stoneware / vitrified clay and reinforced concrete pipes for gravity sewers whereas cast iron / ductile iron pipes are employed for rising / force mains of pumping stations. Concrete pipes conforming to IS :458-1988 of appropriate strength with proper anti-corrosive lining may even last for about 50-60 years. Considering the capital cost, durability and availability of the pipes, RCC pipes, preferably, NP3/NP4 class as per IS:458-1988, have been proposed. Concrete S/S type RCC sewer pipes are usually used

The class of concrete pipes is decided on the basis of analysis of design loads likely to be imposed upon on the sewer depending upon its depth.

3.3.3 Structural Design of Buried Sewers

Any sewer line buried into the ground should have adequate strength to withstand the stresses imposed not only by the internal pressure but more importantly, by the stresses induced by external loads. There are two types of external loads, one is due to the backfill material known as backfill load and other is due to superimposed loads. Besides these external loads, the sewer line is also subjected to the load of water in the pipeline, especially during surcharge conditions.

(1) Load on Conduit due to Backfill

The load on a buried conduit is equal to the weight of the prism of earth directly over the conduit plus the frictional shearing forces transferred to the prism by the adjacent prism of earth. The most widely used method for determining the vertical load due to backfill on buried conduit is Martson’s Formula, the general form of which is

$$W = C.w.B^2$$

where,
W: Vertical load in kg per meter length acting on the conduit due to gravity loads
W: Unit weight of earth, kg/m^3
B: Width of trench or conduit depending upon type of installation condition, m
C: Dimensionless coefficient that measures the effect of ratio of height of fill to width of trench or conduit

The value of C for various types of installation and depending on the height / width ratio is given in the Manual of Sewerage and Sewage Treatment (CPHEEO) published by the Ministry of Urban Development and Poverty Alleviation, New Delhi. The C-value for 'Ordinary maximum for clay' has been considered for design purposes.

The unit weight of earth varies from 1600 kg / m^3 for dry sand to 2100 kg/ m^3 for saturated clay.

(2) Load on Conduit due to Superimposed load

Superimposed loads may be either concentrated or distributed loads. The formula for load due to concentrated load such as truck wheel is given by Boussinesq’s formula

$$W_{sc} = C_s(PF/L)$$

where,
Wsc: load on the conduit, kg/m
P: concentrated load acting on the surface, kg
F: impact factor (1.0 for air field runways, 1.5 for highway traffic and air taxi ways,

1.75 for railway traffic) and
Cs: load coefficient, which is a function of Bc/2H and L/2H, where
H: the height of the top of conduit to ground surface, m
Bc: the outside width of conduit, m and
L: effective length of the conduit to which the load is transmitted, m.

For distributed superimposed loads, the formula for the conduit is given by

Wsd = Cs.p.F.Bc

where,
Wsd: load on conduit, kg/m
P: intensity of distributed load, kg/m2
F: impact factor
Bc: width of conduit, m
Cs: load coefficient, a function of D/2H and L/2H
H: height of the top of conduit to the ground surface, m and D and L are width and length respectively of the area over which the distributed load acts, in meters.

For class AA IRC loading in the critical case of 6.25 tonnes wheel load, the intensity of distributed load with wheel area 300mm x 150mm is given by P = 6.25/(0.3x0.15) T/m^2.

(3) Supporting Strength of Rigid Conduit

The ability of a conduit to resist safely the earth load depends on its inherent strength as well as the distribution of vertical load, bedding reaction and on the lateral pressure acting against the sides of the conduit. The inherent strength of a rigid conduit is usually expressed in terms of the three edge bearing test results, the condition of which are however different from the field load conditions. For strength calculations of NP class precast RCC pipes, IS:458-1988 is used.

(4) Field Supporting Strength

The field supporting strength of a rigid conduit is the maximum load per unit length, which the pipe will support while retaining complete serviceability when installed under specified conditions of bedding and backfilling. The field supporting strength however does not include any factor of safety. The ratio of the strength of a pipe under any stated condition of loading and bedding to its strength measured by the three edge-bearing test is called the load factor. The load factor does not contain a factor of safety. Load factors have been determined experimentally and analytically for the commonly used construction condition for both trench and embankment conduits.

The basic design relationships between the different design elements are:
Safe supporting strength,
W = Field supporting strength/Factor of safety
= (Load factor x three edge bearing strength)/Factor of safety
A factor of safety of at least 1.5 should be applied to the specified minimum three edge bearing strength to determine the working strength for all the rigid conduits. The class of bedding considered is B type, whose load factor as per the CPHEEO Manual is 1.9.

Based on the above consideration, a general guide for selecting the class of pipe from 200 to 600-mm diameter is given in Table: 3-2. However, in our case we have carried out the structural designs for all pipes above 300mm.

Table 3.2 Guideline for Selection of Pipe Class for Sewers with B-class Bedding

Diameter	NP2	NP3	NP4
200	1.2 to 7.0 m	-	-
250	1.2 to 7.0 m	-	-
300	1.2 to 4.2 m	4.2 to 6.0 m	6.0 to 10.0 m
350	1.2 to 2.7 m	2.7 to 3.5 m	3.5 to 10.0 m
400	1.2 to 2.7 m	2.7 to 3.5 m	3.5 to 10.0 m
450	1.2 to 2.7 m	2.7 to 3.5 m	3.5 to 9.5 m
500	-	1.5 to 3.5 m	3.5 to 8.5 m
600	-	1.5 to 3.5 m	3.5 to 7.5 m

Note: For larger diameters of 700-mm and above, pipe class cannot be generalised and has to be calculated on a case to case basis.

3.3.4 Type of Bedding

The type of bedding provided for pipes will be selected from granular bedding, concrete (M20) cradle bedding or concrete encasement (M20) and the choice will depend on the depth at which the sewer is laid, three edge bearing strength of pipes used, load due to backfill and superimposed vehicular traffic loads. Technical suitability of such bedding, as per the guidelines of CPHEEO, is studied and adopted as found acceptable.

3.3.5 Force Main

Sewage may have to be carried to higher elevations through force main. The size of the main should be determined by taking into account the initial cost of pipeline and cost of operation of pumping for different sizes. The size of pressure main has been calculated for velocity of 1.1 to 1.5 m/sec for design peak flows with a maximum velocity up to 2.0 m/sec.

Losses in valves, fittings, etc. are dependent upon the velocity head V2/2g. Loss in bends, elbows depend upon the ratio of absolute friction factor to pipe diameter, besides the velocity head. Loss due to sudden enlargement depends upon the ratio of diameters.

Each individual case needs to be studied from various aspects such as operation of pumps, the specified limits, availability of land required for duplicating the main in future, etc.

CI pipes conforming to IS:1536-1989 and DI pipes as per IS: 8329-1994 are corrosion resistant with an expected life of about 100 years. CI pipes will be jointed either by rubber gaskets suitable tyton joints or by lead joint.

3.4 DESIGN BASIS OF SEWAGE PUMPING STATIONS

3.4.1 Design Approach

The design and selection of pumps for a sewage pumping station involves a multi-disciplinary team of experts who have to work out every detail of the civil, electrical and mechanical aspects in order to obtain a satisfactory design and operation of the pumping station. Different types of pumps have their own purposes and characteristics. There are a series of decisions that have to be taken while selecting and designing the pumps. The various factors considered while designing the pumping station are:

- ➢ Determine location and purpose
- ➢ Determine the required discharge (average and peak flows)
- ➢ Determine the required lift or pressure increase, including the variations therein, as well as the transport distance
- ➢ Determine the type of liquid
- ➢ Determine in and outflow conditions, etc.

- The outline of design procedure can be best laid out in the following Figure 3.1

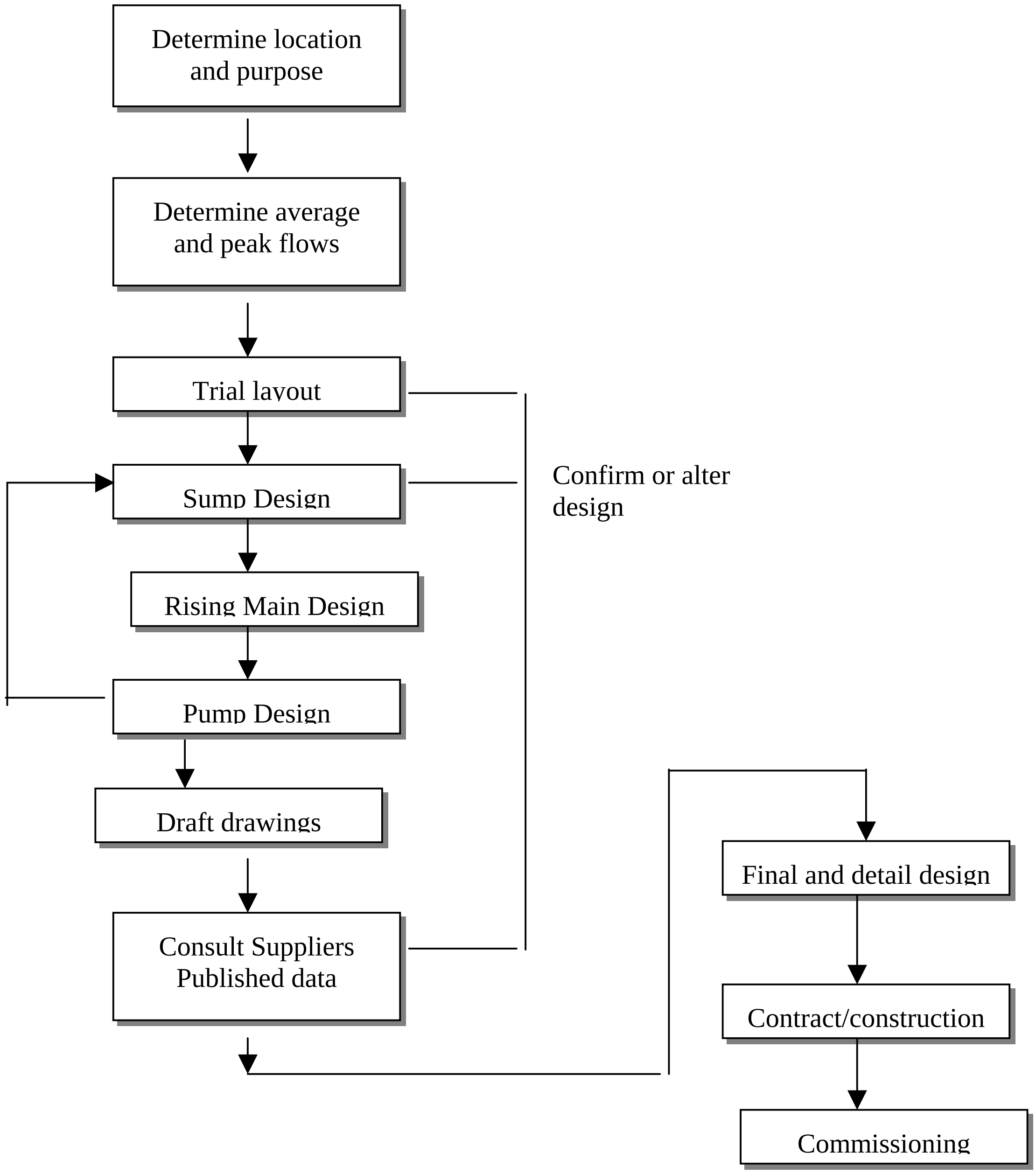


Figure 3.1 Pumping Station Design Procedure

(1) Location and Purpose

Pumping Stations are normally located at the lowest point of the area they are intended to serve. They will frequently, therefore be found alongside the watercourses that drain the area as they are at the natural lowest level.

Proper location of the pumping station requires a comprehensive study of the area to be served to ensure that the entire area can be adequately drained. Special considerations have to be given in undeveloped or developing areas to the probable future growth, as the location of the pumping station will, in many cases, be determined by the future overall development of the area. The site should also be aesthetically satisfactory. The pumping station shall be located and constructed in such a manner that it will not be flooded at any time. The station should be easily accessible under all weather conditions.

(2) Determination of Flows

Having decided the location of the pumping station, its purpose and the contributory area, the next stage is to calculate average and peak flows for the present day and a point in the future at a set "design horizon'. Whilst in the structural sense, concrete structures are designed for 30-50 years, they are normally sized to deal with the peak flow at a 30 year horizon.

(3) Layout

The layout of pumping stations will primarily depend upon the local conditions. In general, it can be said that the layout of a pumping station is logic fit of all functions of the station, with sufficient room to move between machinery for erection and maintenance purposes, but without unnecessary empty spaces neither in a horizontal plane nor in vertical direction. In principle, flow lines shall be as short as possible and no unnecessary bends shall be present in the piping.

Spaces are required for the following units.

- Inlet chamber
- Screen chamber
- Main Collection Sump
- Valve chamber/ Dry well
- Transformer station
- Electrical panel room
- DG set room
- Operations Office

Two type of pump house layout is considered based on type of pumps:

- Dry well and wet well for horizontal centrifugal pumps
- Wet well and valve chamber for submersible pumps

All spaces should be well lighted. Also, outside lighting may be required. Proper railings are required along stairs or on platforms. Sufficient space shall be available for future expansion of the station.

(4) Design of Pumping Station

Pump sizing is carried out with reference to manufacturer's catalogues, as these are the most reliable guides.

Sump Design

a) Wet Well

Capacity of wet well sump is decided based on CPHEEO Manual and NRCD guidelines depending on the selection of either submersible or horizontal centrifugal type of pumps. The well must be self-cleansing and hence benching is provided on the floor of the sump.

b) Dry Well/ valve Chamber

Sizing of Dry well (for horizontal centrifugal pumps) or Valve chamber (for submergible pumps) has been designed considering common header diameter, fittings, valves, working space and operating space.

(5) Rising main Design

The concept of rising main design is to meet following criteria:

The main must be self cleaning with minimum flows

- velocities shall not be excessive at design peak flows
- Techno-economic diameter of rising main is calculated considering capitalised cost of pumps and rising main for 15 years

Technical evaluation for selection of pumps is presented in Annexure A3.1

3.4.2 Design Criteria for Sewage Pumping Stations

(1) Design Year

For the design of civil structures	2030
For the design of mechanical and electrical items	2015
For the design of rising main	2015

(2) Wet well Capacity

Detention time of wet well at peak flow	5 minutes for horizontal centrifugal pumps 3.75 minutes for submersible pumps

(3) Dry Well/ Valve Chamber Size

Based on number of pumps and clear spacing requirement for pumps, pumps dimension, valves, fittings and working space requirement.

(4) Rising Main

The pump capacity together with rising main diameter shall be calculated considering pump cost, rising main cost and annual operation & maintenance cost. Lesser diameter rising main may be cheaper in initial cost but the operation cost may be high due to increased pump head.
The most economical size of the rising main should be selected after analysing following factors:

- The different diameter of pipes for different head losses, which can be considered for the quantity of sewage intended to be transported.
- The design period and the quantum of flow to be carried out for design period.
- The pipe and its relative cost including cost of laying and jointing.
- The cost of pump and its installation against the various diameters of pipes.
- The annual and capitalised cost of electric charges.
- Minimum required velocity self cleansing in pipe line (should be 0.6 m/sec) during non-peak condition.
- Maximum allowable velocity in pipe line (should not be more than 2.0 m/sec)

(5) Pumps

The design criteria for ascertaining the number of pumps and the pumping capacity are presented in this sub-section.

Number of pumps for small capacity pumping stations

i) When rising main is long	a) 3 nos. pumps of half-peak flow b) 2 nos. pumps of non-peak flow

ii) When rising main is short	a) 5 nos. pumps of one-fourth peak flow

Number of pumps for large capacity pumping stations

Equal capacity pumps (6 to 8) + 50% standby on peak flow

Above criteria is basic NRCD guideline for selection of number of pumps. However, the final decision on pump configuration is taken based on availability of pump capacity in market.

Moreover, a technical evaluation of various types of pumps has been done and the same is presented in Annex A3.1. Based on the technical evaluation, considering advantages, disadvantages, and also the past experiences of UPJN officials on existing installations, it was decided and recommended that for the various sewage pumping stations in Kanpur, submersible pumps shall be opted only up to 150 HP capacity and horizontal centrifugal pumps shall be opted for higher (>150 HP) capacities.

Pump capacity and power charges

Pump capacity in kW 9.81 * H * Q/ (Ep * Em)
where,
H = working pressure, m
Q = pump discharge, m3/sec
Ep = pump efficiency
Em = motor efficiency

Electrical power charges Rs. 3.25 per unit
Capitalised energy charges CC = CR *{ [1 – (1+r) ^ (-n)]/ r }
where,
CR = annual energy charges
n = period in years = 15 or 30
r = rate of interest = 10% or 5%
For n = 15 & r = 10%; CC = 7.61 CR and
For n = 30 & r = 5%; CC = 15.37 CR

(6) Screens & Screen Channel

Screening of incoming sewage is required for the removal of large floating materials, which can damage the pumps. This will be carried out in two stages, viz. 40 mm opening manually cleaned bar screen followed by a 20 mm opening mechanically cleaned bar screen.

Standby Units	100 % (normally)

Stage - I

Clear spacing between screen bar	40 mm
Thickness of screen bar	10 mm
Type of working screens	Manual screen

Stage - II

Clear spacing between screen bar	20 mm
Thickness of screen bar	10 mm
Type of working screens	Mechanical screen
Type of standby screen	Manual screen
Minimum approach velocity @ avg. flow	0.3 m/sec
Minimum velocity through screens	0.6 m/sec
Maximum velocity through screens	1.2 m/sec

(7) Electrical Load Capacity

Main Transformer and other electrical equipments are designed for peak flow electrical load requirement.

(8) Standby Power Supply Source

In case of electrical power failure, Diesel Generator sets of average flow load capacity are proposed for sewage pumping stations with auto exchanger arrangement from grid power to DG power.

3.5 DESIGN BASIS FOR SEWAGE TREATMENT PLANTS

3.5.1 Criteria for Selection of STP site

The main criteria governing the choice for the location of STP site are,

- Topography of the contributing area (sewerage zone)
- Usage of existing sewerage system
- Proximity to the discharge point for the treated sewage
- Location of discharge of the treated sewage from intake of water works
- Availability and accessibility of site for the STP
- Location of the selected site for STP vis-à-vis the City
- Availability of other utilities like power, roads, communications etc.
- Capitalized Operation and Maintenance costs

In Kanpur, under priority sewerage projects, a STP of 200mld capacity has been proposed at Panka and Augmentation of an existing STP of 130 mld at Jajmau has been considered.

Topography of the contributing area (sewerage zone)

The Kanpur City is divided into various sewerage districts considering topography and natural drainage system. These sewerage zones are marked on the base map and is presented in the drawing no. KAN-BASE MAP-1.

Usage of existing sewerage system

Proposed STP at Panka will have capacity to treat sewage generated in Sewerage District-III for year 2015. Whereas the augmentation of existing STP at Jajmau has been proposed to treat excess flow received at MPS from Sewerage District I.

Proximity to the discharge point for the treated sewage

It is necessary to locate the proposed plant at a suitable site from where the treated sewage can be safely discharged. The treated sewage from the Panka STP will be used for irrigation purpose in the surrounding area and the excess sewage will be safely disposed off in river Pandu that is passing near the STP site. Treated sewage from Jajmau STP will also be used for irrigation purpose and the excess flow will be disposed off in River Ganga.

Location of discharge of the treated sewage from intake of water works

It is very essential that the location of discharge point of treated sewage into receiving body is on the downstream side of the water intake points for water supply system. The discharge point envisaged for the proposed STPs is far away from the raw water intake points and on the downstream side of the city.

Availability and accessibility of site for the STP

It is essential to have proper access roads to the STP location. The site identified for the proposed Panka STP, which is accessible from the GT road. A road already exists from GT road up to the STP site.

A***vailability of other utilities like power, roads, communications etc.***

The STP sites proposed under the Master Plan is easily approachable. The site is located on a proper road network, which ensures that other utilities such as power, communication facilities can be made available.

Capitalised Operation and Maintenance Costs

Looking at the existing sewerage facilities, all above factors which have influence on the selection of STP locations do not have any adverse impact on the capital costs as well as on the operation & maintenance costs and the existing facilities will be utilised to fullest possible extent.
After the detailed discussions it is found that the locations identified for the proposed STPs is most suitable.

3.5.2 Raw Sewage Characteristics Considered for Design Purpose

The wastewater characteristics for the proposed sewage treatment plant at Panka is based on the projected wastewater characteristics presented in the Table 3.3.
The following wastewater characteristics are used for design of sewage treatment plant.

Table 3.3 Raw Sewage Characteristics Considered for Design Purpose

Sr.	Parameter	Average Value
1.	Minimum temperature, ^{o}C	20
2.	pH	6.0 - 8.5
3.	Biochemical oxygen demand (BOD_5), mg/l	230
4.	Total suspended solids, mg/l	500
5.	Faecal coliform count, MPN/100ml	1×10^6

3.5.3 Discharge Standards

The sewage treatment plant shall be designed so as to achieve treated wastewater of equal or better quality as mention in the table 3-4 hereunder.

Table 3.4 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	Desired $\leq$1,000 Permissible $\leq$10,000

NRCD have conveyed the recommendations of the Expert Committee through their 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. It is also mentioned in NRCD guidelines that BOD and TSS concentration less than 30 mg/l and 50 mg/l, respectively.

3.5.4 Approach for Selection of Sewage Treatment Schemes

(1) Power Supply Situations in India and in Uttar Pradesh

Power Supply Situations in Uttar Pradesh

UP has currently possesses power generation capacity of 4,693 MW: 4,192 MW by thermal generation and 501 MW by hydraulic power. In addition, UP has a share of 2,855 MW in central sector generation in the northern region. The peak power demand for 2004-2005 was 7,877 MW out of which 5,268 MW could be met, indicating the peak power shortage was 21 %. The shortage is expected to decrease to 5 % by various measures described below. When the new projects such as Rihand II, Tehri, Dhauliganga and Unchatar III are commissioned, some 3,200 MW capacity will be added.

Beside the new installation of power plants, four measures have been taken to enhance power supply in UP: renovation and modernization of existing plants, more effective transmission and distribution network, organizational reforms and introduction of non conventional energy sources.

Renovation and modernization of existing plants

Unit new installation cost is said to be Rs. 4 crore/MW, while the unit cost to renovate and modernize old power plants is said to be Rs. 0.5 – 1.5 crore/MW, which implies that renovation and modernization is more cost effective depending upon how long the plants have been operated and how they are maintained. Some of the old plants were already renovated and some others are expected to follow them.

More effective transmission and distribution network

The transmission and distribution losses in UP were 35% in 2003, the highest in India. The losses are attributed to inadequate investment, metering inefficiencies and theft. To solve the problems, the investment will concentrate on highly densely networks leading to quick and visible results, 100% feeder metering and as well as consumer metering are targeted, and transformation capacity will be enhanced.

(2) Approach for Selection of Sewage Treatments Scheme

The requirements of a feasible sewage treatment system are as following:

- Simple to construct and operate,
- Ability to handle strong sewage within short detention time,
- Minimum capital and operation cost, Possibility of cost recovery,
- Minimum land requirement,
- Ability to treat up to the prescribed discharge standards,
- Minimum odour, flies and other nuisance, and
- General acceptance to the people in the vicinity of the STP.

3.5.5 Treatment Options for Use of Treated Water for Irrigation Purpose

The techno-economic treatment option should take into consideration the site-specific constraints and the inlet characteristics of the sewage. Further, for a city of Kanpur, which is fast growing, and with huge quantum of sewage being generated every day with high organic load, the treatment option should not be separately looked into without considering the land costs.

Following four options have been evaluated for finalising the sewage treatment scheme:

a) Alternative 1 : Waste Stabilisation Pond System consisting of Anaerobic Pond followed by Facultative pond followed by Maturation pond,
b) Alternative 2 : Activated Sludge Process with Chlorination System,
c) Alternative 3 : Upflow anaerobic sludge blanket (UASB) Process followed by Aerated lagoon with Chlorination System,
d) Alternative 4 : Aerated lagoon followed by Maturation Ponds with Chlorination System,

Alternative 1 : Waste Stabilisation Pond System of Anaerobic Pond + Facultative + Maturation Pond

Stabilisation ponds are open, flow through earthen basins specially designed and constructed to treat sewage and biodegradable industrial wastewater. Stabilisation ponds provide long detention periods extending to several days. In ponds the organic waste is stabilised through symbiotic relationship between the algae and bacteria. Oxygen is provided by photosynthesis of algae or by mechanical aeration in some cases.

The treatment process will consist of inlet chamber, screen channel, and an anaerobic pond having hydraulic retention time of 2 days. The facultative pond having a detention time of 16 days will follow the anaerobic pond. Subsequent to the facultative pond, there shall be maturation ponds having detention time of 1 days. The waste stabilization ponds are designed for ambient temperature of 20 degree Celsius.

Table 3.5 Area Statement for Waste Stabilization Pond System

Sr.	Unit	Detention time (day)	Depth (m)
1	Anaerobic lagoon	2	3.0
2	Facultative pond	16	2.0
3	Maturation pond	1	1.2

The schematic flow diagram of this Alternative is presented in the Figure 3.2.

Alternative 2 : Activated Sludge Process with Chlorination System

An activated sludge process (ASP) is a type of aerobic suspended growth system. The ASP plant essentially consist of the following:

Aeration tank containing microorganisms in suspension in which biological degradation of organic matter takes place aerobically,
Activated sludge recirculation system to maintain the sufficient microorganisms in aeration tank,
Excess sludge wasting and disposal facilities,

- Aeration system to transfer oxygen, and
- Secondary settling tank to settle the suspended solids,
- Thickener to thicken activated sludge,
- Digester for sludge digestion,
- Gasholder for gas storage resulting from sludge digestion,
- Chlorination system for disinfecting treated sewage.

This Alternative consists of the following treatment units-

- Inlet chamber,
- Fine screen channel,
- Grit removal,
- Primary settling tank,
- Aeration tank,
- Secondary clarifier,
- Chlorination system,
- Sludge pumping station,
- Filtrate pumping station,
- Sludge thickener,
- Sludge digester,
- Gasholder and
- Sludge drying beds.

The design parameters for this alternative is presented in Table 3.6.

Table 3.6 Design Parameters for ASP with Chlorination System

Sr.	Parameters	Value	Unit
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° C	2.65	
	Efficiency	75	%
4.	Primary Clarifier		
	Surface overflow rate at average flow	35	cum/sqm/day
	Detention time	2.05	hours
5.	Aeration Tank		
	F/M	0.30	
	MLSS	2,500	mg/l
	MLVSS/MLSS	0.8	
	O_2 provided	1.2	Kg O_2/kg BOD removed
6.	Secondary Clarifier		
	Surface overflow rate at average flow	25	cum/sqm/day
	Detention time	3.07	hours
7.	Chlorine Mixing Tank		
	Detention time	2	mins
8.	Chlorine Contact Tank		
	Detention time	30	mins
9.	Sludge Thickener		
	Rate of solids surface loading	50	kg/sqm/day
10.	Primary Sludge Digester		
	SRT	15	days
	Ratio of diameter to depth	3.74	
11.	Secondary Sludge Digester		
	SRT	10	days
	Ratio of diameter to depth	3.75	
12.	Gas Holder		
	Detention time	6	hours
	Pressure	0.03	kg/sqcm

Raw sewage will be received in the inlet chamber and then passed to the screen channel and subsequently to the grit removal. In screen channel floating matters are trapped and removed whereas in grit chamber, grit is removed. After screening and grit removal the wastewater is taken into a primary Clarifier. This is provided for the removal of suspended matter before taking wastewater for further biological treatment. The sludge generated as a result of primary settling is taken for thickening and subsequently for digestion. A sludge digester and pumps are provided for this purpose.

After primary settlement of the suspended matter, the wastewater is taken to aeration tank containing microorganisms in suspension in which the biological degradation takes place. Further, a secondary clarifier is provided to separate the activated sludge. A part of the incoming flow is re-circulated upstream of the aeration tank. A tapping is provided on this line to lead the excess sludge to the sludge sump.

A two-stage digestion system is provided for sludge digestion. The detention time in the digester is

about 20 days. Mixers are provided to operate in a completely mixed regime in the digester. It is proposed to use sludge-drying beds for sludge dewatering prior to sludge disposal.
The schematic flow diagram of this Alternative is presented in the Figure 3.3.

Alternative 3: UASB Process followed by Aerated lagoon with Chlorination

The UASB process followed by aerated lagoon with chlorination essentially consist of the following:

- Primary treatment consisting of screening and grit removal,
- UASB reactor for anaerobic degradation of sewage,
- Aerated lagoon having aeration system to transfer oxygen,
- Chlorination system for further reduction of faecal coliform and disinfecting treated sewage.
- Gasholder for gas storage and Gas utilisation system, and
- UASB Sludge wasting and dewatering facilities,

The treatment process will consist of the following treatment units:

- Inlet Chamber,
- Fine Screen Channel,
- Grit chamber,
- UASB Reactors
- Aerated lagoon,
- Chlorination System,
- Sludge Pumping Station,
- Filtrate Pumping Station,
- Gas Utilisation System, and
- Sludge Drying Beds.

The design parameter of this alternative is presented in Table 3.7.

Table 3.7 Design Parameters for UASB followed by AL with Chlorination

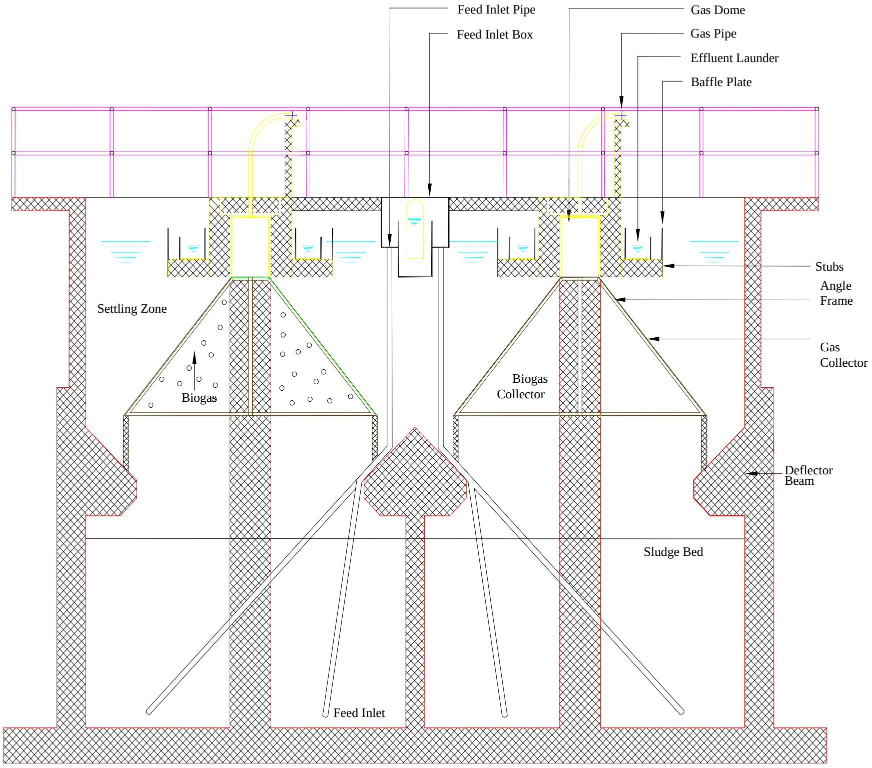
Sr.	Parameter	Value	Unit
Average flow		1.157	cum/sec
Peak factor		2.0	
Peak flow		2.315	cum/sec
Sewage Treatment Plant:			
1.	Inlet Chamber		
	Hydraulic retention time (minimum)	30	sec
2.	Fine Screen Channel		
	Clear opening through screen	6	mm
	Minimum approach velocity at average flow	0.3	m/sec
	Minimum 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° 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

UASB Technology

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

- Treated wastewater usable for 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.

UASB initially was developed for the anaerobic treatment of industrial wastewater with a moderate to high COD and BOD concentrations. The basic idea is 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 basin 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. Organic compounds there after 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 H, hydrogen sulphide H_2S and traces of ammonia NH_3 and nitrogen N_2. This biogas can be used as energy source and for this reason is collected in gas collectors.



A typical cross section of UASB Reactor

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 with the wastewater flow are settled in the settling zone and slide down into the biological reaction zone. Wastewater enters the UASB reactor from the bottom and travels through the 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.

With proper seed material available at the time of start-up of the UASB reactor, the microbial population is developed within three months period. 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 having the following zones:

- Gas collection zone
- Clarification zone
- Sludge blanket zone

Effluent from UASB reactor will not meet the discharge standards for BOD and TSS, hence, further treatment is required. Therefore, post treatment in the form of AL is provided to meet these standards.

Aerated lagoons are generally provided in the form of simple earthen basins with inlet at one end and outlet at the other to enable the wastewater to flow through while aeration is usually provided by mechanical means to stabilise the organic matter. The major difference between activated sludge systems and aerated lagoons is that in the latter, settling tanks and sludge recirculation is absent.

Aerated lagoons can be categorised into two types depending on how the microbial mass of solids in the system is handled. Aerated lagoons are those in which some solids may leave with the effluent stream and some settle down in the lagoon since aeration power input is just enough for oxygenation and not for keeping all solids in suspension. As the lower part of such lagoons may be anoxic and anaerobic while the upper layers are aerobic, the term facultative is used.

Aerobic lagoons, on the other hand, are fully aerobic from top to bottom as the aeration power input is sufficiently high to keep all the solids in suspension besides meeting the oxygenation needs of the system. No settlement occurs in such lagoons and under equilibrium conditions the new (microbial) solids produced in the system equal the solids leaving the system. Thus, the solids concentration in the effluent is relatively high and some further treatment is generally provided after such lagoons. If the effluent is settled and the sludge recycled, the aerobic lagoon, in fact, becomes an activated sludge or extended aeration type lagoon.

Facultative type aerated lagoons have been more commonly used the world over because of their simplicity in operation and minimum need of machinery. They are often referred to simply as ‘aerated lagoons’. Their original use came as a means of upgrading overloaded oxidation ponds in some countries without adding to the land requirement. In fact, much less land is required compared to oxidation ponds.

Moreover, chlorination is carried out for disinfecting the wastewater to meet discharge guideline for faecal coliform as per the latest NRCD norms. Disinfection refers to the selective destruction of diseases-causing organisms. Diseases caused by waterborne bacteria include typhoid, cholera, paratyphoid, and bacillary dysentery; diseases caused by waterborne viruses include poliomyelitis and infectious hepatitis. At present, the most common method of disinfecting wastewater is by the addition of chlorine.

The schematic flow diagram of this alternative is presented in the Figure 3.4.

Alternative 4 : Aerated lagoon followed by Maturation Pond with Chlorination System

Aerated lagoons are generally provided in the form of simple earthen basins with inlet at one end and outlet at the other to enable the wastewater to flow through while aeration is usually provided by mechanical means to stabilise the organic matter. The major difference between activated sludge systems and aerated lagoons is that in the latter, settling tanks and sludge recirculation is absent.

Aerated lagoons can be categorised into two types depending on how the microbial mass of solids in the system is handled. Aerated lagoons are those in which some solids may leave with the effluent stream and some settle down in the lagoon since aeration power input is just enough for oxygenation and not for keeping all solids in suspension. As the lower part of such lagoons may be anoxic and anaerobic while the upper layers are aerobic, the term facultative is used.

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A maturation pond is shallow earthen pond, which is provided for polishing of effluent from aerated lagoons. This is an aerobic pond as the depth of this pond is restricted to 1.2 m. In maturation pond, BOD and suspended solids are further reduced, aerobically, to meet the wastewater discharge standards. Table 3.8 contains the design parameter for this alternative.

Table 3.8 Design Parameters for AL Followed by Maturation Pond with Chlorination

Sr.	Parameters	Value	Unit
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.	Aerated lagoon		
	Temperature	20	^{o}C
	HRT	6	days
	D/UL	1.0	
	Minimum power required	0.75	W/cum
	Detention time in settling zone	12.86	hours
5.	Maturation Pond		
	Detention time	2.0	days
6.	Chlorine Mixing Tank		
	Detention time	2	mins
7.	Chlorine Contact Tank		
	Detention time	30	mins

The schematic flow diagram of this Alternative is presented in the Figure 3.5.

Evaluation of Treatment Scheme Alternatives

As discussed, four treatment alternatives have been considered for the proposed 100 mld capacity, in phase I, sewage treatment plant at Panka. The cost comparison for the treatment alternatives is presented in Table 3.9.

For augmentations of STP at 130 mld capacity STP at Jajmau, augmentation is proposed with the same sewage treatment scheme already existing for the plant.

Table 3.9 Cost Comparison of Treatment Alternatives for STP at Panka

Sr.	Units	Alternative 1 : Waste Stabilisation Ponds	Alternative 2 : Activated Sludge Process + Chlorination	Alternative 3 : UASB + Aerated lagoon + Chlorination	Alternative 4 : Aerated lagoon + Maturation Pond + Chlorination
I	Qualitative Factors				
a.	Location of land	At Panka village in Kanpur	At Panka village in Kanpur	At Panka village in Kanpur	At Panka village in Kanpur
b.	Is land available at existing site?	No	Yes	Yes	No
c.	Ease of Operation	Comparatively easy	Moderate	Moderate	Moderate
d.	Possibility of Biogas Production?	No	Yes	Yes	No
e.	Possibility of Sludge Production?	No	Yes	Yes	No
f.	Treated Sewage Characteristics: • BOD, mg/l • TSS, mg/l • Faecal coliform, MPN/100ml	<30 <50 <10,000	<30 <50 <10,000	<30 <50 <10,000	<30 <50 <10,000
g.	Likely problem areas • Odour • Seasonal variability • Ground water pollution • Mosquito nuisance potential	High Maximum High High	Moderate Minimum Minimum Moderate	Localized Minimum Moderate Minimal	High Maximum High High
h.	Potential for meeting WHO Bacteriological guidelines for irrigation	Suitable for unrestricted irrigation	Suitable for unrestricted irrigation	Suitable for unrestricted irrigation	Suitable for unrestricted irrigation
II	Quantitative Factors				
A.	Cost (Rs.)				
1.	Capital Cost				
	Civil cost	384,721,919	268,795,688	235,032,725	170,143,408
	Mechanical cost	7,314,000	73,383,763	27,764,505	58,944,000
	Electrical & Instrumentation cost	6,680,496	44,081,060	33,650,403	32,974,220
	Total Civil, E & M Cost	398,716,415	386,260,511	296,447,633	262,061,628
2.	STP Utilities	16,790,000	15,765,000	14,580,000	15,340,000
3.	Total Capital Cost (Rs.)	415,506,415	402,025,511	311,027,633	277,401,628
B.	Land Requirement				
	Area required for 100 mld, ha	101.21	20.24	16.15	55.87
	Land Cost (Rs.) (@Rs. 100,000 per Ha)	101,214,575	20,242,915	16,150,000	55,870,445
C.	O & M Cost per annum				
	Total O & M Cost	6,025,440	40,765,247	16,158,607	32,172,180
D.	Summary Cost Analysis				
	Total Capital Cost including Land Cost	516,720,990	452,268,426	361,027,633	333,272,073
	O & M Cost per year	6,025,440	40,765,247	16,158,607	32,172,180
	Resource Recovery*	0	6,500,000	6,200,000	0
	Capitalized Cost (1)	609,346,771	979,009,257	514,115,831	827,837,335
	Ranking	II	IV	I	III
	Capitalized Cost (2)	562,550,966	712,892,619	436,773,590	577,976,232
	Ranking	II	IV	I	III

Note :

+ Source : Finance & Revenue Dept., Govt. of Uttar Pradesh
(1) : Capitalised Cost calculated for 30 years at interest rate of 5%
(2) : Capitalised Cost calculated for 15 years at interest rate of 10%
: Cost recovered through Resource Recovery is not considered while working out the Capitalised Cost.

(1) Discussion on the Treatment Options

Each treatment alternative has some positive and some negative aspects to it. These are discussed below with reference to certain key factors.

Process Performance

The treatment schemes proposed under the four alternatives are suitable and technically viable to meet NRCD guidelines for treated sewage discharge. All the treatment schemes are time tested proven treatment schemes.

Inference

All four-treatment processes satisfy the Process Performance criteria as these will meet the discharge standards as stipulated by NRCD for land irrigation as well as for river discharge.

Seasonal Variability

As regards coliform removal, the performance of the ponds considered in the Alternatives nos. 1 & 4 will be reduced substantially in the winter months due to low temperatures. While in summer months, coliform removal will improve but effluent BOD will increase owing to algae in the effluent. This effect will not be so pronounced in the alternative of UASB followed by Aerated Lagoon owing to the dampening effect of the UASB. The third alternative will be least affected by seasonal variations.

Inference

The third alternative namely, UASB followed by Aerated Lagoon with chlorination, is the most suitable treatment process from the Seasonal Variability aspect as it is least affected by the temperature variations.

Environmental Impact

Ground Water

There is a possibility of ground water contamination in case of first and fourth alternatives due to seepage from the holding area of the ponds although as a precaution all the ponds are proposed to be lined at considerable cost. This possibility is minimum in case of Alternative no. 2 as well as Alternative no. 3. Since, the aerated lagoon has the least detention time and therefore, least contact surface with the soil. The aerated lagoon will also be lined

Mosquito

Mosquito breeding in the pond is generally caused due to weed growth and marginal vegetation in badly maintained ponds. Fly breeding may be another problem if the ponds are not maintained well. Hence, this problem can occur only in badly maintained ponds, which are more likely, in large size ponds as in Alternative nos. 1 & 4.

Odour

In summer months, blue green algae may grow vigorously in the pond, giving rise to floating mats of algae. The algae in the mats may then die and give rise to odours. Some odorous sulphides may also be generated in warmer months. Due to mechanical aeration in the second and third alternatives, odour problem is not foreseen, which could occur in the other alternative nos. 1 and 4. The UASB may at worst give a slight localized odour problem

Inference

The third alternative of UASB followed by Aerated Lagoon with Chlorination is the most suitable treatment process as it has minimal adverse environmental impact on the population. No odour and mosquito problem is envisaged due to aeration. In comparison to the other alternatives, the holding area of the aerated lagoon, which will also be lined, is very small and there is a minimal possibility of ground water contamination due to seepage.

Land Availability

The available land of 90 hectares is adequate for the Alternatives nos. 2, 3 & 4. The land requirement for the alternative no. 1 is higher and found substantially more than the available land.

Inference

The alternative nos. 2, 3 & 4 are feasible treatment process from the Land Availability viewpoint. However, the alternative nos. 2 & 3 has the least quantum of land requirement.

Resource Recovery

The treatment alternative nos. 2 & 3 only offer the avenue for resource recovery from the sewage treatment. The by-products of ASP and UASB system are biogas and excess sludge. The biogas formed can be utilized as an energy source and the sludge as manure. The operation & maintenance cost can be partly recovered from the sale of these products. This benefit is available with both the second and third treatment alternatives. The other two alternatives do not offer any resource recovery.

Inference

The second and third alternatives are equally beneficial from the Resource Recovery viewpoint as both generate biogas and sludge, which can partly reduce the operating costs.

Capitalised Costs

The Capitalized Cost of the treatment alternatives is based on Capital Cost, O&M Cost as well as Resource Recovery. The costs are annualised for 15 years at an interest rate of 10%.

Inference

The third alternative is the least from the Capitalised Cost viewpoint as it has the lowest Present Worth in comparison to the other three treatment alternatives.

Recommendation

It can finally be concluded that “Alternative 3: UASB followed by Aerated lagoon with Chlorination System” is best suited for the proposed 100 mld capacity sewage treatment plant at Panka. The process will comply with the all the relevant discharge standards as well as being the most economically viable.

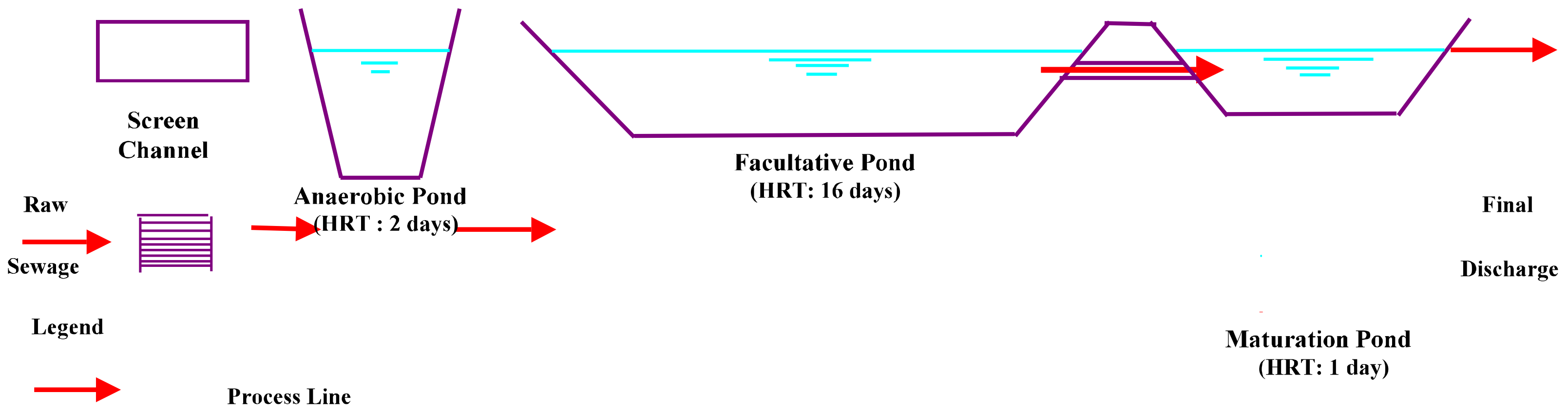


Figure 3.2 Schematic Flow Diagram for Waste Stabilisation Pond

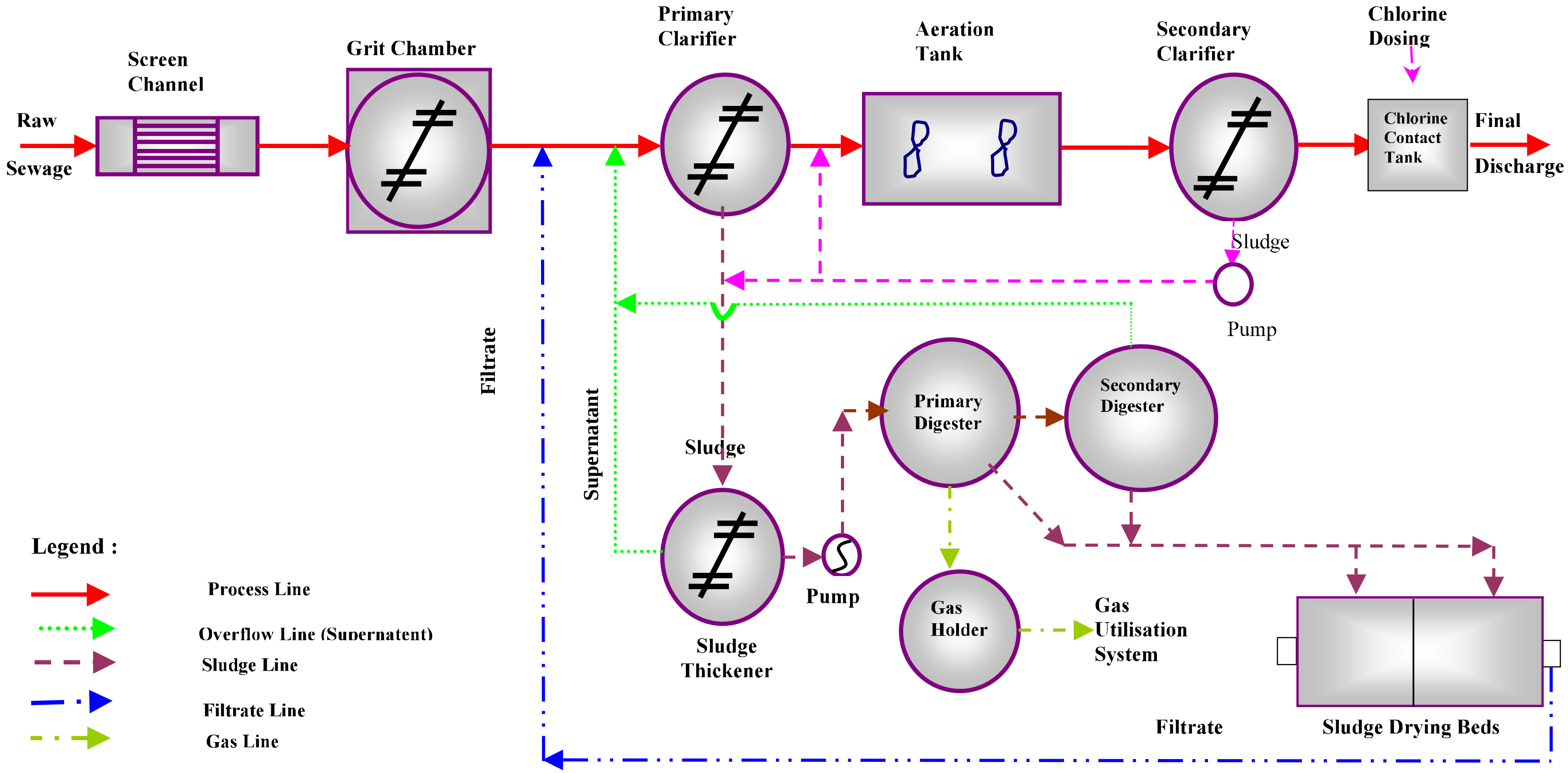


Figure 3.3 Schematic Flow Diagram for Activated Sludge Process with Chlorination System

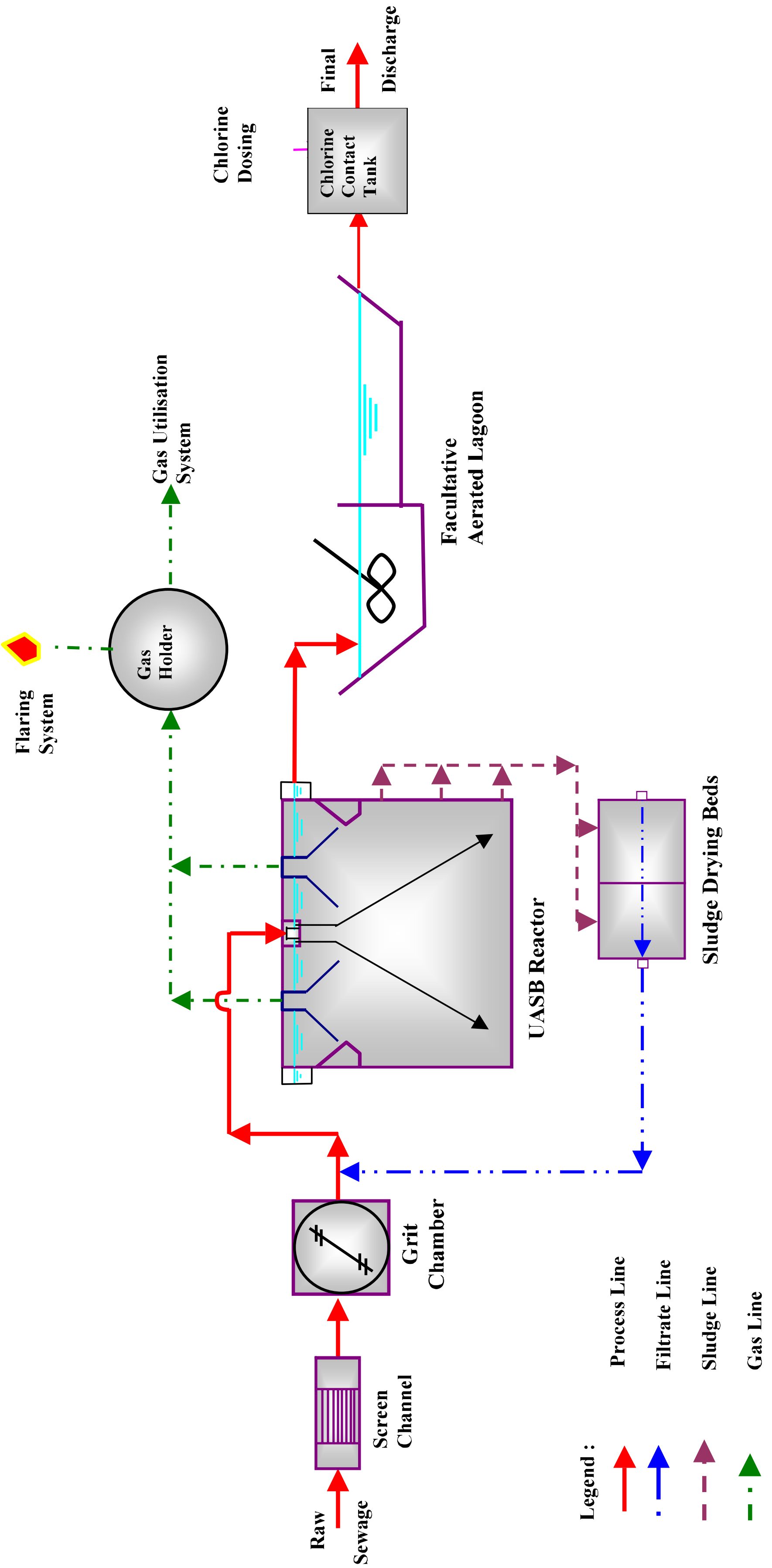


Figure 3.4 Schematic Flow Diagram for UASB Process Followed by Aerated Lagoon with Chlorination System

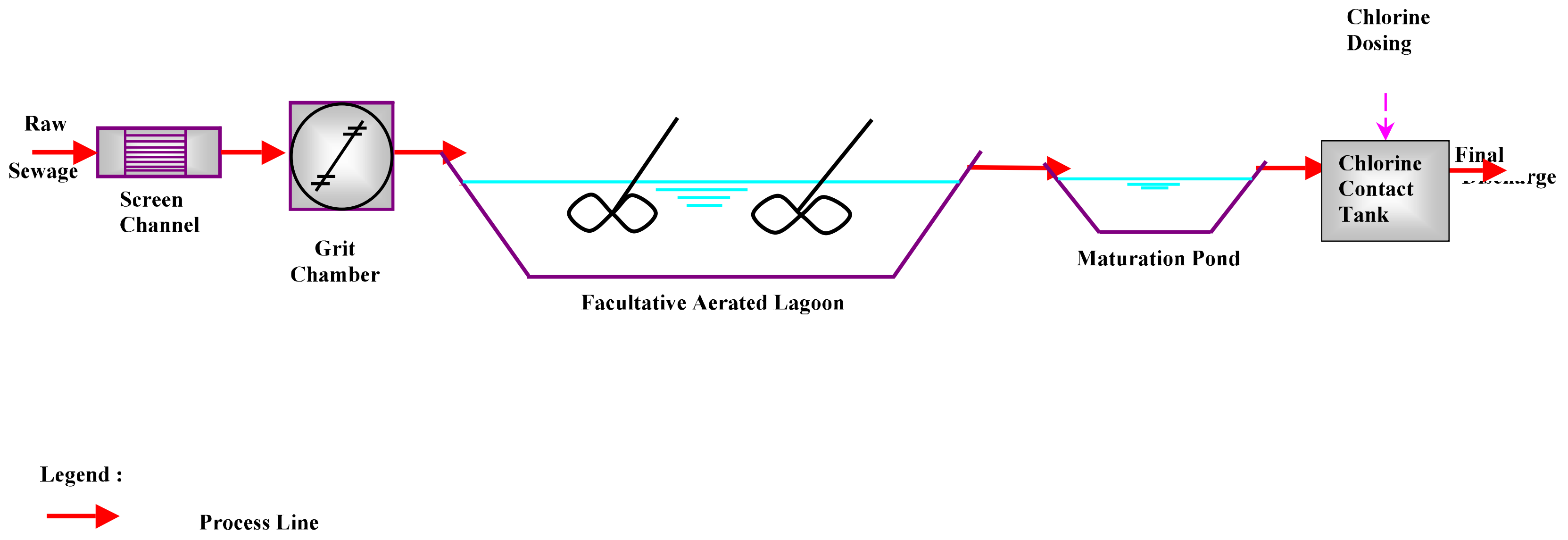


Figure 3.5 : Schematic Flow Diagram for Facultative Aerated Lagoon Followed by Maturation Pond with Chlorination

CHAPTER 4

PRELIMINARY DESIGN OF SEWERAGE NETWORK

CHAPTER 4 PRELIMINARY DESIGN OF SEWERAGE NETWORK

4.1 SEWERAGE DISTRICT I

The Sewerage District I, is bounded by the river Ganga to the north, H.B.T.I (Hercourt Butler Technological Institute) and roadways workshop to the west, Armapur Estate, Dada Nagar, Kidwai Nagar and COD nala in the south. This area includes the old city core with the old sewerage network dating back to as early as 1910.

Priority projects defined under Master Plan for this sewerage District I include,

1) Installation of new domestic sewer network for Jajmau tannery industrial area.
2) Tapping facility of Bhagwatdas ghat nala by constructing a new pumping station (the pumping station is detailed in Section 5 and tapping facility is explained in 4.1.10)
3) Replacement of sewers in District I (replacement of existing trunk sewer from Rawatpur (I3a) to Hudson school crossing (H) and relief trunk sewer from Hudson school to Cantonment.
4) Tapping and conveying facility of wastewater from Sisamau nala.
5) Assessment of physical condition by reconnaissance survey as well as assessment of capacity of existing Jajmau pumping station considering present and future flows.
6) Assessment of physical condition by reconnaissance survey as well as assessment of capacity of existing sewage treatment plant (ASP) at Jajmau by considering the present and future flows.
7) Assessment of physical condition of existing four pumping stations viz Parmat , Nawab ganj, Muir mill, and Guptar ghat by reconnaissance survey as well as assessment of capacities of these pumping stations considering the present and future flows.

In addition to above Master Plan priority projects, during field survey and discussion with UPJN officials, sewer replacement of damaged existing 60” trunk sewer from Golf club (near Panchghari ghat) to Chhabilepurva has been included in the priority projects.

Designs and cost estimates for the proposed new and replacement sewers including new gravity sewer for Jajmau tannery area are presented in this section, whereas other proposed components of, pumping station and sewage treatment plant are presented in relevant sections of the report.

4.1.1 Review /Collection of Existing Documents

JICA Study Team provided the following documents regarding District I waste water collection conveyance and treatment facilities

- Influent and effluent wastewater characteristics for treatment plants at Jajmau
- Census data 2001 for wards administrated by Kanpur Municipal Corporation
- UPJN Kanpur sewerage reorganisation Master Plan 1979-2001
- Drawings having information regarding four-ghat pumping stations and treatments plants and CSPS at Jajmau.
- Detailed information regarding projects being executed during Indo-Dutch scheme

These have been reviewed by MWH to understand the concepts and practical situation at the project site.

4.1.2 Need of Domestic Sewer for Jajmau Area

During implementation of Indo Dutch schemes to convey tannery wastes upto 36 mld industrial waste treatment plant, surface channels were laid keeping in view that all the tannery wastes form different tanneries will be connected to the surface channels only. But as per the ground reality there are quite a few tanneries whose connections are directly to the 90" domestic trunk sewer. This very fact is causing problems at 130 mld treatment plant, which is meant for only domestic sewage. Therefore a need to separate this illegal connection of industrial waste to the domestic wastewater collection and treatment facilities is felt.

4.1.3 Master Plan Provisions

The Master plan states that the tannery area should have a separate collection system for its domestic wastewater so that it could be collected and conveyed directly to the UASB. All the existing connections to the 90" sewer shall be disconnected and later connected to the new proposed domestic sewer meant for tanner area only.

4.1.4 Survey work executed

MWH has carried out following survey works on this alignment

Reconnaissance Survey
Topographical Survey
Geo Technical Survey

(1) Reconnaissance Survey

A reconnaissance survey was conducted from September 29th 2004 with the help of UP Jal Nigam officials. The survey was carried out from PS1 to common sewage pumping station (CSPS) at Jajmau.

(2) Topographical Survey

Topographical survey was carried out throughout the roads from Purani Chungi to combined sewage treatment plant as well as 150 feet wide road from Chhabile purwa to combined sewage treatment plant. Topographical survey was also conducted along the connecting internal roads of Jajmau area. The total distance of survey done is 10.65 km.

(3) Geo Technical Survey

In order to know the soil profiles of the alignment, two nos. of 10m deep boreholes were bored, one on each road (mentioned above) of the Jajmau industrial area.
Soil assessment reports are as under:-

The under laying soil strata is plastic in nature consisting of clayey silt of low plasticity (CL group) up to 6 to 7 m. The N values in plastic strata are 6 to 17 indicating medium to very stiff consistency. Non plastic silty sand (SM group) is met from 6to 10 m. The water table has not been met in the boreholes.

4.1.5 Design Engineering Works

Designs of domestic trunk and lateral sewers for Jajmau area is presented in this section, which falls in Sewerage District I of Kanpur city

(1) Design population and flows

Ward-wise population figures finalised under Master Plan for the Jajmau are considered area for designing the domestic sewerage network. Based on the topography of the project area and the surveys conducted, the alignment of the gravity sewer has been finalised. Nodal populations contributing to the flows on the nodes are derived considering the catchment areas considered in the Master Plan and the general topography.

A summary table presenting the contributing population for year 2015 and 2030 along with the sewage conveyed is presented in Table 4.1.

Table 4.1 Catchment Details of Domestic Sewer for Jajmau Area

Gravity Sewer	**Year 2015**		**Year 2030**	
	Population Covered (Nos.)	**Average Flow (mld)**	**Population Covered (Nos.)**	**Average Flow (mld)**
Domestic sewer for Jajmau area	136,053	19.73	169,358	26.25

(1) Design of domestic sewer for Jajmau area

Catchment area of the domestic sewer for Jajmau area has been presented in Drawing No.KAN-CA-D1-2. The sewer line is designed for year 2030.

The diameter and pipe class wise design summary of the domestic trunk sewer and lateral sewer for Jajmau area is presented in Table 4.2 and Table 4.3, respectively.

Table 4.2 Pipe Length Details of Domestic Sewer for Jajmau Area, Lateral Sewer

Sr.	**Diameter (mm)**	**Length of NP3 pipe (m)**
1	300	400
2	400	250
3	450	350
4	500	850
5	600	1,060
6	700	975
	Total	3,885

Table 4.3 Pipe Length Details for Jajmau Area, Trunk Sewer

Sr.	**Diameter (mm)**	**Length of NP3 pipe (m)**
1	800	690
2	900	510
3	1200	330
4	1400	1,050
5	1600	1,950
	Total	4,530

Table 4.4 (1) Hydraulic Design of Domestic Sewer for Jajmau Area

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	No of Pipes	Dia Obtained	Dia Recomended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumulative length	UGL	DGL	UIL	DIL	Drop
							M^3/sec	M^3/sec		M^3/sec	No	mm	mm	1 in				m/sec	M^3/sec	M	M	(M)	(M)	(M)	(M)	(M)
1	JJM_N1	JJM_N2	10220	24526	34746	34746	0.062	0.062	2.50	0.156	1.00	445.55	800	1000	0.37	0.47	0.78	0.65	0.16	120	120	116.96	117.12	113.61	113.49	0.1
2	JJM_N2	JJM_N3			0	34746	0.000	0.062	2.50	0.156	1.00	445.55	800	1000	0.37	0.47	0.78	0.65	0.16	120	240	117.12	118.81	113.49	113.37	
3	JJM_N3	JJM_N4			0	34746	0.000	0.062	2.50	0.156	1.00	445.55	800	1000	0.37	0.47	0.78	0.65	0.16	90	330	118.81	119.32	113.37	113.28	
4	JJM_N4	JJM_N5			0	34746	0.000	0.062	2.50	0.156	1.00	445.55	800	1000	0.37	0.47	0.78	0.65	0.16	90	420	119.32	121.39	113.28	113.19	
5	JJM_N5	JJM_N6			0	34746	0.000	0.062	2.50	0.156	1.00	445.55	800	1000	0.37	0.47	0.78	0.65	0.16	150	570	121.39	121.01	113.19	113.04	
6	JJM_N6	JJM_N7			0	34746	0.000	0.062	2.50	0.156	1.00	445.55	800	1000	0.37	0.47	0.78	0.65	0.16	120	690	121.01	119.91	113.04	112.92	
7	JJM_N7	JJM_N8	6524		6524	41270	0.012	0.074	2.50	0.185	1.00	485.58	900	1200	0.35	0.46	0.77	0.64	0.19	120	810	119.91	117.93	112.82	112.72	0.1
8	JJM_N8	JJM_N9			0	41270	0.000	0.074	2.50	0.185	1.00	485.58	900	1200	0.35	0.46	0.77	0.64	0.19	60	870	117.93	116.96	112.72	112.67	
9	JJM_N9	JJM_N10			0	41270	0.000	0.074	2.50	0.185	1.00	485.58	900	1200	0.35	0.46	0.77	0.64	0.19	60	930	116.96	114.90	112.67	112.62	
10	JJM_N10	JJM_N11			0	41270	0.000	0.074	2.50	0.185	1.00	485.58	900	1200	0.35	0.46	0.77	0.64	0.19	150	1080	114.90	114.31	112.62	112.49	
11	JJM_N11	JJM_N12			0	41270	0.000	0.074	2.50	0.185	1.00	485.58	900	1200	0.35	0.46	0.77	0.64	0.19	120	1200	114.31	114.29	112.49	112.39	
12	JJM_N12	JJM_N13	1857	33722	35579	76849	0.064	0.138	2.25	0.310	1.00	628.61	1200	2000	0.35	0.46	0.77	0.60	0.31	90	1290	114.29	114.56	112.09	112.05	0.3
13	JJM_N13	JJM_N14			0	76849	0.000	0.138	2.25	0.310	1.00	628.61	1200	2000	0.35	0.46	0.77	0.60	0.31	45	1335	114.56	114.30	112.05	112.02	
14	JJM_N14	JJM_N15			0	76849	0.000	0.138	2.25	0.310	1.00	628.61	1200	2000	0.35	0.46	0.77	0.60	0.31	75	1410	114.30	114.21	112.02	111.99	
15	JJM_N15	JJM_N16			0	76849	0.000	0.138	2.25	0.310	1.00	628.61	1200	2000	0.35	0.46	0.77	0.60	0.31	120	1530	114.21	114.64	111.99	111.93	
16	JJM_N16	JJM_N17	4373	22133	26506	103355	0.048	0.185	2.25	0.417	1.00	729.01	1400	2400	0.35	0.46	0.77	0.60	0.42	120	1650	114.64	115.58	111.73	111.68	0.2
17	JJM_N17	JJM_N18			0	103355	0.000	0.185	2.25	0.417	1.00	729.01	1400	2400	0.35	0.46	0.77	0.60	0.42	120	1770	115.58	118.08	111.68	111.63	
18	JJM_N18	JJM_N19			0	103355	0.000	0.185	2.25	0.417	1.00	729.01	1400	2400	0.35	0.46	0.77	0.60	0.42	90	1860	118.08	119.00	111.63	111.59	
19	JJM_N19	JJM_N20			0	103355	0.000	0.185	2.25	0.417	1.00	729.01	1400	2400	0.35	0.46	0.77	0.60	0.42	90	1950	119.00	118.55	111.59	111.55	
20	JJM_N20	JJM_N21			0	103355	0.000	0.185	2.25	0.417	1.00	729.01	1400	2400	0.35	0.46	0.77	0.60	0.42	120	2070	118.55	120.82	111.55	111.50	
21	JJM_N21	JJM_N22			0	103355	0.000	0.185	2.25	0.417	1.00	729.01	1400	2400	0.35	0.46	0.77	0.60	0.42	90	2160	120.82	122.08	111.50	111.46	
22	JJM_N22	JJM_N23	6498	8457	14955	118310	0.027	0.212	2.25	0.478	1.00	779.97	1400	2400	0.40	0.49	0.80	0.62	0.48	120	2280	122.08	121.68	111.46	111.41	
23	JJM_N23	JJM_N24			0	118310	0.000	0.212	2.25	0.478	1.00	779.97	1400	2400	0.40	0.49	0.80	0.62	0.48	120	2400	121.68	119.05	111.41	111.36	
24	JJM_N24	JJM_N25			0	118310	0.000	0.212	2.25	0.478	1.00	779.97	1400	2400	0.40	0.49	0.80	0.62	0.48	180	2580	119.05	113.89	111.36	111.29	
25	JJM_N25	JJM_N26	6319	11552	17871	136181	0.032	0.244	2.25	0.550	1.00	836.80	1600	3000	0.36	0.46	0.77	0.59	0.55	150	2730	113.89	113.63	111.09	111.04	0.2
26	JJM_N26	JJM_N27			0	136181	0.000	0.244	2.25	0.550	1.00	836.80	1600	3000	0.36	0.46	0.77	0.59	0.55	90	2820	113.63	113.80	111.04	111.01	
27	JJM_N27	JJM_N28			0	136181	0.000	0.244	2.25	0.550	1.00	836.80	1600	3000	0.36	0.46	0.77	0.59	0.55	210	3030	113.80	118.51	111.01	110.94	
28	JJM_N28	JJM_N29			0	136181	0.000	0.244	2.25	0.550	1.00	836.80	1600	3000	0.36	0.46	0.77	0.59	0.55	120	3150	118.51	121.63	110.94	110.90	
29	JJM_N29	JJM_N30			0	136181	0.000	0.244	2.25	0.550	1.00	836.80	1600	3000	0.36	0.46	0.77	0.59	0.55	60	3210	121.63	122.70	110.90	110.88	
30	JJM_N30	JJM_N31			0	136181	0.000	0.244	2.25	0.550	1.00	836.80	1600	3000	0.36	0.46	0.77	0.59	0.55	60	3270	122.70	122.34	110.88	110.86	
31	JJM_N31	JJM_N32			0	136181	0.000	0.244	2.25	0.550	1.00	836.80	1600	3000	0.36	0.46	0.77	0.59	0.55	210	3480	122.34	115.87	110.86	110.79	
32	JJM_N32	JJM_N33			0	136181	0.000	0.244	2.25	0.550	1.00	836.80	1600	3000	0.36	0.46	0.77	0.59	0.55	120	3600	115.87	113.64	110.79	110.75	
33	JJM_N33	JJM_N34			0	136181	0.000	0.244	2.25	0.550	1.00	836.80	1600	3000	0.36	0.46	0.77	0.59	0.55	60	3660	113.64	113.68	110.75	110.73	
34	JJM_N34	JJM_N35	33176		33176	169357	0.060	0.304	2.25	0.684	1.00	933.18	1600	3000	0.44	0.52	0.83	0.63	0.68	150	3810	113.68	117.83	110.73	110.68	
35	JJM_N35	JJM_N36			0	169357	0.000	0.304	2.25	0.684	1.00	933.18	1600	3000	0.44	0.52	0.83	0.63	0.68	150	3960	117.83	121.65	110.68	110.63	
36	JJM_N36	JJM_N37			0	169357	0.000	0.304	2.25	0.684	1.00	933.18	1600	3000	0.44	0.52	0.83	0.63	0.68	210	4170	121.65	120.53	110.63	110.56	
37	JJM_N37	JJM_N38			0	169357	0.000	0.304	2.25	0.684	1.00	933.18	1600	3000	0.44	0.52	0.83	0.63	0.68	150	4320	120.53	117.99	110.56	110.51	
38	JJM_N38	JJM_PS			0	169357	0.000	0.304	2.25	0.684	1.00	933.18	1600	3000	0.44	0.52	0.83	0.63	0.68	210	4530	117.99	117.00	110.51	110.44	

Table 4.4 (2) Hydraulic Design of Domestic Sewer for Jajmau Area

Hydraulic Design for sewer from Moti nagar road to Purani chungi in Jajmau area

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recomended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumulative length	UGL	DGL	UIL	DIL	Drop
							M^3/sec	M^3/sec		M^3/sec	mm	1 in				m/sec	M^3/sec	M	M	(M)	(M)	(M)	(M)	(M)
1	JJM_N1/1	JJM_N1/2	14477	0	14477	14477	0.026	0.026	3.00	0.078	500	750	0.56	0.60	0.89	0.63	0.08	200	200	122.76	120.18	118.76	118.49	
2	JJM_N1/2	JJM_N1/3	0	0	0	14477	0.000	0.026	3.00	0.078	500	750	0.56	0.60	0.89	0.63	0.08	200	400	120.18	118.70	116.99	116.73	1.5
3	JJM_N1/3	JJM_N1/4	4258	0	4258	18735	0.008	0.034	3.00	0.101	600	900	0.49	0.55	0.85	0.62	0.10	150	550	118.70	119.18	116.13	115.96	0.6
4	JJM_N1/4	JJM_N1/5	5791	0	5791	24526	0.010	0.044	2.50	0.110	600	900	0.54	0.58	0.88	0.63	0.11	200	750	119.18	116.00	114.76	114.54	1.2
5	JJM_N1/5	JJM_N1/6	0	0	0	24526	0.000	0.044	2.50	0.110	600	900	0.54	0.58	0.88	0.63	0.11	120	870	116.00	115.98	114.44	114.30	0.1
6	JJM_N1/6	JJM_N1/7	0	0	0	24526	0.000	0.044	2.50	0.110	600	900	0.54	0.58	0.88	0.63	0.11	120	990	115.98	116.26	114.20	114.07	0.1
7	JJM_N1/7	JJM_N1	0	0	0	24526	0.000	0.044	2.50	0.110	600	900	0.54	0.58	0.88	0.63	0.11	120	1110	116.26	116.96	113.97	113.84	0.1

Hydraulic Design for sewer from Ganga vihar to inustrial area at Jajmau

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recomended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumulative length	UGL	DGL	UIL	DIL	Drop
							M^3/sec	M^3/sec		M^3/sec	mm	1 in				m/sec	M^3/sec	M	M	(M)	(M)	(M)	(M)	(M)
1	JJM_N12/1	JJM_N12/2	22333	0	22333	22333	0.040	0.040	2.50	0.100	600	800	0.46	0.53	0.84	0.64	0.10	200	200	122.79	122.41	119.29	119.04	
2	JJM_N12/2	JJM_N12/3	0	0	0	22333	0.000	0.040	2.50	0.100	600	800	0.46	0.53	0.84	0.64	0.10	150	350	122.41	121.88	118.94	118.75	0.1
3	JJM_N12/3	JJM_N12/4	7203	0	7203	29536	0.013	0.053	2.50	0.132	700	900	0.43	0.51	0.82	0.66	0.13	275	625	121.88	120.80	117.55	117.25	1.2
4	JJM_N12/4	JJM_N12/5	0	0	0	29536	0.000	0.053	2.50	0.132	700	900	0.43	0.51	0.82	0.66	0.13	150	775	120.80	120.09	117.15	116.98	0.1
5	JJM_N12/5	JJM_N12/6	4186	0	4186	33722	0.008	0.060	2.50	0.151	700	900	0.49	0.55	0.85	0.68	0.15	200	975	120.09	119.44	116.38	116.16	0.6
6	JJM_N12/6	JJM_N12	0	0	0	33722	0.000	0.060	2.50	0.151	700	900	0.49	0.55	0.85	0.68	0.15	350	1325	119.44	113.81	113.06	112.67	3.1

Hydraulic Design for sewer from police chowki near chungi at Lukhnow road to tennery road crossing

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recomended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumulative length	UGL	DGL	UIL	DIL	Drop
							M^3/sec	M^3/sec		M^3/sec	mm	1 in				m/sec	M^3/sec	M	M	(M)	(M)	(M)	(M)	(M)
1	JJM_N16/1	JJM_N16/2	16478	0	16478	16478	0.030	0.030	3.00	0.089	500	600	0.57	0.61	0.90	0.71	0.09	200	200	120.67	119.23	116.17	115.83	
2	JJM_N16/2	JJM_N16	0	0	0	16478	0.000	0.030	3.00	0.089	500	600	0.57	0.61	0.90	0.71	0.09	250	450	119.23	114.64	113.33	112.92	2.5

Hydraulic Design for sewer laid parellel to Lukhnow road to tennery road crossing

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recomended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumulative length	UGL	DGL	UIL	DIL	Drop
							M^3/sec	M^3/sec		M^3/sec	mm	1 in				m/sec	M^3/sec	M	M	(M)	(M)	(M)	(M)	(M)
1	JJM_N16A/1	JJM_N16A/2	5655	0	5655	5655	0.010	0.010	3.00	0.030	300	500	0.70	0.69	0.95	0.58	0.03	200	200	114.95	114.78	113.75	113.35	
2	JJM_N16A/2	JJM_N16	0	0	0	5655	0.000	0.010	3.00	0.030	300	500	0.70	0.69	0.95	0.58	0.03	200	400	114.78	114.64	113.35	112.95	

Hydraulic Design for sewer from Alphan tannery to Mercury tannery in Jajmau area

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recomended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumulative length	UGL	DGL	UIL	DIL	Drop
							M^3/sec	M^3/sec		M^3/sec	mm	1 in				m/sec	M^3/sec	M	M	(M)	(M)	(M)	(M)	(M)
1	JJM_N22/1	JJM_N22/2	8457		8457	8457	0.015	0.015	3.00	0.046	400	500	0.49	0.55	0.85	0.63	0.05	100	100	121.30	121.67	116.80	116.60	
2	JJM_N22/2	JJM_N22			0	8457	0.000	0.015	3.00	0.046	400	500	0.49	0.55	0.85	0.63	0.05	150	250	121.67	122.08	113.00	112.70	3.6

Hydraulic Design for sewer from Resham mill to Hanumanjiki bagichi in Jajmau area

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recomended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumulative length	UGL	DGL	UIL	DIL	Drop
							M^3/sec	M^3/sec		M^3/sec	mm	1 in				m/sec	M^3/sec	M	M	(M)	(M)	(M)	(M)	(M)
1	JJM_N25/1	JJM_N25/2	11552	0	11552	11552	0.021	0.021	3.00	0.062	450	600	0.53	0.58	0.88	0.64	0.06	150	150	120.58	116.32	116.08	115.83	
2	JJM_N25/2	JJM_N25	0	0	0	11552	0.000	0.021	3.00	0.062	450	600	0.53	0.58	0.88	0.64	0.06	200	350	116.32	113.89	112.83	112.49	3.0

4.1.6 Cost Estimates

Budgetary cost estimation for the sewer was carried out based on schedule of rates and prevailing market rates and is tabulated below.

Table 4.5 Cost estimation of Domestic Sewer for Jajmau Area -Trunk Sewer

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
1	Excavation				
(a)	Excavation for depth up to 1.5 m below G.L for laying Sewer manholes ordinary soil (earth, sand loam and clay) including cutting of joints pits ramming dressing) levelling, refilling of trenches in 20 cm layer watering and ramming the same including removal of surplus earth or other dismantled material up to a distance of 50 m. from the centre of trenches.				
	(a) 0 to 1.5 m depth	Cum	61	17,543	1,070,123
	(b) 1.5 to 3 m depth	Cum	75	15,669	1,175,175
	(c) 3 to 4.5 m depth	Cum	93	11,685	1,086,705
	(d) 4 .5to 6 m depth	Cum	107	9,159	980,013
	(e) 6.0 to 7.5 m depth	Cum	140	7,549	1,056,860
	(f) 7.5m to 9.0 m depth	Cum	184	4,795	882,280
	(g) 9.0m to 10.5 m depth	Cum	240	3,084	740,160
	(h) 10.5m to 12.00 m depth	Cum	312	1,714	534,768
	(i) 12.0m to 13.5 m depth	Cum	406	125	50,750
(b)	Same as item 1(a) but excavation in soil mixed with kankar and boulders				
	(a) 0 to 1.5 m depth	Cum	294	4,386	1,289,484
	(b) 1.5 to 3 m depth	Cum	338	3,918	1,324,284
	(c) 3 to 4.5 m depth	Cum	393	2,922	1,148,346
	(d) 4 .5to 6 m depth	Cum	452	2,290	1,035,080
	(e) 6.0 to 7.5 m depth	Cum	541	1,888	1,021,408
	(f) 7.5m to 9.0 m depth	Cum	663	1,199	794,937
	(g) 9.0m to 10.5 m depth	Cum	812.51	771	626,447
	(h) 10.5m to 12.00 m depth	Cum	995.74	429	427,173
	(i) 12.0m to 13.5 m depth	Cum	1,005.70	32	32,182
2	Shuttering				
(a)	Provide and fix close timbering in trenches for the depth up to 3 m o 3m below G.L consisting of 40 mm thick approved country wood plank for polling board 125 x 75 mm Indian Sal wood walers and 100 mm dia sal wood ballies for shutting at 1.50m C/C including removal after laying of sewers (both sides of trenches) will be taken as one side for the purpose of payment and measurement i.e. area equals to Length x depth of trenches, Dismantled, timbering material will be the property of the Contractor. Details of cost for 30 m and 3 m deep trench i.e. 90 Sq M area of timbering				
	(a) 0 to 3 m	Sqm	176	6,695	1,178,320
	(b) 3 to 6 m	Sqm	224	4,503	1,008,672
(b)	Same as item no.2 (a) but timbering left in trenches *(unused timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	1,392	1751	2,437,392
	(b) 9 to 12 m	Sqm	1,600	704	1,126,400
	(c) 12 to 15 m	Sqm	1,840	19	34,960
(c)	Same as item no.2 but timbering left in trenches*(used timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	584	1168	682,112

Sr.	**Items**	**Units**	**Rate (Rs.)**	**Quantity**	**Amount (Rs.)**
	(b) 9 to 12 m	Sqm	670	470	314,900
	(c) 12 to 15 m	Sqm	770	13	10,010
3	Supply of following sizes of RCC spigotted and socketed non pressure pipes				
	(a) 800 mm dia in 1.25 m length	m	2,311.75	690	1,595,104
	(b) 900 mm dia in 1.25 m length	m	2,784.76	510	1,420,229
	(c) 1200 mm dia in 1.25 m length	m	4,507.84	330	1,487,587
	(d) 1400 mm dia in 1.25 m length	m	5,926.83	1050	6,223,170
	(e) 1600 mm dia in 1.25 m length	m	7,651.57	1950	14,920,555
4	Laying jointing of RCC hume pipe				
	Carting following sizes of R.C.C Hume pipe (NP3 Class Socket /spigoted rubber ring jointed and specials from store to the work lowering the same in to the trenches in depth up to 1.5m below G.L true to alignment including excavation of earth below G.L invert level of pipe, cost of all jointing material, testing etc, complete but excluding excavation and refilling of trenches from ground level to the invert level of pipe.				
	800 mm dia pipe				
	(a)3.0 - 4.50 m	m	747	180	134,460
	(b) 4.5 - 6.0 m	m	797	150	119,550
	(c) 6.0 - 7.5 m	m	869	114	99,066
	(d) 7.5 - 9.0 m	m	965	246	237,390
	900 mm dia pipe				
	(a)1.5 - 3.00 m	m	827	294	243,138
	(b)3.0 - 4.50 m	m	878	54	47,412
	(c) 4.5 - 6.0 m	m	938	102	95,676
	(d) 6.0 - 7.5 m	m	1,021	60	61,260
	1200 mm dia pipe				
	(a)1.5 - 3.00 m	m	1,315	330	433,950
	1400 mm dia pipe				
	(a) 1.5 - 3.00 m	m	1,668	42	70,056
	(b) 3.0 - 4.50 m	m	1,771	189	334,719
	(c) 4.5 - 6.0 m	m	1,891	93	175,863
	(d) 6.0 - 7.5 m	m	2,061	297	612,117
	(e) 7.5 - 9.0 m	m	2,289	75	171,675
	(f) 9.0 - 10.50m	m	2,563	216	553,608
	(g) 10.50- 12.0 m	m	2,898	138	399,924
	1600 mm dia pipe				
	(a)1.5 - 3.00 m	m	2,010	360	723,600
	(b)3.0 - 4.50 m	m	2,135	170	362,950
	(c) 4.5 - 6.0 m	m	2,280	164	373,920
	(d) 6.0 - 7.5 m	m	2,484	380	943,920
	(e) 7.5 - 9.0 m	m	2,760	287	792,120
	(f) 9.0 - 10.50m	m	3,090	300	927,000
	(g) 10.50- 12.0 m	m	3,493.00	291	1,016,463
5	Sand filling				
	Sand filling below ground level including supply of all materials labour T & P etc required for proper completion of work				
	(a) 1.5 m to 3.0 m	Cum	204.384	807	164,938
	(b) 3.0 m to 4.5 m	Cum	217.056	517	112,218
	(c) 4.50 m to 6.0 m	Cum	231.84	319	73,957
	(d) 6.0 m to 7.5 m	Cum	252.576	158	39,907
	(e) 9.0 m- 10.50m	Cum	314.208	119	37,391
	(f) 10.50m- 12.0 m	Cum	355.2	198	70,330
6	PCC (Plain cement concrete)				
	Cement concrete work in bedding below ground level with cement , coarse sand and 20 mm gauge approved stone ballast (1:2:4)				

Sr.	**Items**	**Units**	**Rate (Rs.)**	**Quantity**	**Amount (Rs.)**
	including supply of all materials, labour, T & P etc, required for the proper completion of work				
	(a) 1.5 m to 3.0 m	Cum	2,641.02	9	23,769
	(b) 3.0 m to 4.5 m	Cum	2,804.77	30	84,143
	(c) 4.50 m to 6.0 m	Cum	2,995.81	55	164,769
	(d) 6.0 m to 7.5 m	Cum	3,263.76	339	1,106,413
	(e) 7.5 m to 9.0 m	Cum	3,625.98	146	529,393
	(f) 9.0 m- 10.50m	Cum	4,060.16	106	430,377
	(g) 10.50m- 12.0 m	Cum	4,589.85	45	206,543
7	RCC (Reinforced concrete cement)	Cum	3,988	972	3,876,899
8	Constructing vent shafts	Nos.	16,000	10	160,000
9	Construction of Scrapper manhole 2.43 mx1.53m				
	(a) up to depth 4.57m	Nos.	80,318	43	3,453,674
	(b) upto depth 9.14m	Nos.	14,189	105	1,489,845
	(c) upto depth 14.0 m	Nos.	22,040	23	506,920
10	Construction of manhole dia 1.52m				
	(a) upto depth 2.28m (type B1)	Nos.	19,352	29	561,208
	(b) upto depth 5.03m (type B2)	Nos.	6,088	56	340,928
	(c) upto depth 9.14m (type B3)	Nos.	6,747	38	256,386
11	Construction of manhole dia 1.82m				
	(a) upto depth 2.28m (type C1)	Nos.	26,914	8	215,312
	(b) upto depth 5.03m (type C2)	Nos.	8,715	2	17,430
12	Construction of manhole dia 2.43 mx1.53m				
	(a) upto depth 4.57m (type D1)	Nos.	68,200	72	4,910,400
	(b) upto depth 9.14m (type D2)	Nos.	15,539	227	3,527,353
	(c) upto depth 14.00 m(type D3)	Nos.	22,136	54	1,195,344
13	Road restoration				
	Dismantling of tar road for laying sewer including shorting out and stacking serviceable materials and disposal of unserviceable materials upto distance of 60 m and its rein statement after filling and proper compaction of trenches. Based on the nagar Mahapalika, P.W.D , VNS	Sqm	1,250	15,363	19,203,750
14	Shifting of electric and telephone cables				
	Provision for shifting and reinstatement of electric and telephone cable etc. during excavation and laying of sewer lines	LS			200,000
15	Shifting of temporary water supply lines				
	Provision for temporary shifting of existing sewers and water supply falling in the alignment of conveying main during excavation and the restoring utilities/ services to its original condition	LS			200,000
	Total cost				99,805,020 **(99,805,000)**

Table 4.6 Cost Estimation of Domestic Sewer for Jajmau Area-Lateral Sewer

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
1	Excavation				
(a)	Excavation for depth up to 1.5 m below G.L for laying Sewer manholes ordinary soil (earth, sand loam and clay) including cutting of joints pits ramming dressing) levelling, refilling of trenches in 20 cm layer watering and ramming the same including removal of surplus earth or other dismantled material upto a distance of 50 m. from the centre of trenches.				
	(a) 0 to 1.5 m depth	Cum	61	8,777	535,397
	(b) 1.5 to 3 m depth	Cum	75	6,835	512,625
	(c) 3 to 4.5 m depth	Cum	93	4,533	421,569
	(d) 4 .5to 6 m depth	Cum	107	1,666	178,262
	(e) 6.0 to 7.5 m depth	Cum	140	599	83,860
	(f) 7.5m to 9.0 m depth	Cum	184	196	36,064
(b)	Same as item 1(a) but excavation in soil mixed with kanklar and boulders				
	(a) 0 to 1.5 m depth	Cum	294	2,195	645,330
	(b) 1.5 to 3 m depth	Cum	338	1,709	577,642
	(c) 3 to 4.5 m depth	Cum	393	1,134	445,662
	(d) 4 .5to 6 m depth	Cum	452	417	188,484
	(e) 6.0 to 7.5 m depth	Cum	541	150	81,150
	(f) 7.5m to 9.0 m depth	Cum	663	49	32,487
2	Shuttering				
(a)	Provide and fix close timbering in trenches for the depth up to 3 m o 3m below G.L consisting of 40 mm thick approved country wood plank for polling board 125 x 75 mm Indian Sal wood walers and 100 mm dia sal wood ballies for shutting at 1.50m C/C including removal after laying of sewers (both sides of trenches) will be taken as one side for the purpose of payment and measurement i.e. area equals to Length x depth of trenches, Dismantled, timbering material will be the property of the Contractor. Details of cost for 30 m and 3 m deep trench i.e. 90 Sq M area of timbering				
	0 to 3 m	Sqm	176	5,417	953,392
	3 to 6 m	Sqm	224	2,496	559,104
(b)	Same as item no.2(a) but timbering left in trenches*(unused timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	1,392	221	307,632
(c)	Same as item no.2 (a) but timbering left in trenches*(used timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	584	147	85,848
3	Supply of following sizes of RCC spigotted and socketed non pressure pipes				
	(a) 300 mm dia in 1.25 m length	m	358.86	400	143,54
	(b) 400 mm dia in 1.25 m length	m	847.54	250	211,884
	(c) 450 mm dia in 1.25 m length	m	979.97	350	342,988
	(d)500 mm dia in 1.25 m length	m	1,026.72	850	872,713
	(e) 600 mm dia in 1.25 m length	m	1,512.64	1060	1,603,401
	(f) 700 mm dia in 1.25 m length	m	1,788.71	975	1,743,993
4	Laying jointing of RCC hume pipe				
	Carting following sizes of R.C.C hume pipe (NP3 Class Socket /spigoted rubber ring jointed and specials from store to the work lowering the same in to the trenches in depth upto 1.5m below G.L true to alignment including excavation of earth below G.L invert level of				

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
	pipe, cost of all jointing material, testing etc, complete but excluding excavation and refilling of trenches from ground level to the invert level of pipe. (300 mm dia)				
	Rate per meter at different depth				
	(a) 0- 1.5 m	m	206.00	280	57,680
	(b)1.5 - 3.00 m	m	220.00	120	26,400
	400 mm dia pipe				
	(c) 4.5 - 6.0 m	m	322.00	100	32,200
	(d) 6.0 - 7.5 m	m	350.00	45	15,750
	(e) 7.5 - 9.0 m	m	389.00	75	29,175
	(f) 9.0 - 10.50m	m	436.00	30	13,080
	450 mm dia pipe				
	(a) 3.0 - 4.50 m	m	368.00	230	84,640
	(b) 4.5 - 6.0 m	m	393.00	120	47,160
	500 mm dia pipe				
	(a)1.5 - 3.00 m	m	395.00	250	98,750
	(b)3.0 - 4.50 m	m	420.00	500	210,000
	(c) 4.5 - 6.0 m	m	448.00	100	44,800
	600 mm dia pipe				
	(a)1.5 - 3.00 m	m	492.00	536	263,712
	(b)3.0 - 4.50 m	m	523.00	524	274,052
	700 mm dia pipe				
	(a)1.5 - 3.00 m	m	560.00	70.	39,200
	(b)3.0 - 4.50 m	m	595.00	615.	365,925
	(c) 4.5 - 6.0 m	m	636.00	220.	139,920
	(d) 6.0 - 7.5 m	m	692.00	70.	48,440
5	Sand filling				
	Sand filling below ground level including supply of all materials labour T & P etc required for proper completion of work				
	(a) 1.5 m to 3.0 m	Cum	204.384	280	57,228
	(b) 3.0 m to 4.5 m	Cum	217.056	74	16,062
	(c) 4.50 m to 6.0 m	Cum	231.840	29	6,723
	(d) 6.0 m to 7.5 m	Cum	252.576	10	2,526
	(e) 7.5 m to 9.0 m	Cum	280.608	16	4,490
	(f) 9.0 m- 10.50m	Cum	314.208	7	2,199
6	PCC (Plain cement concrete)				
	Cement concrete work in bedding below ground level with cement , coarse sand and 20 mm gauge approved stone ballast (1:2:4) including supply of all materials, labour, T & P etc, required for the proper completion of work.				
	(a) 1.5 m to 3.0 m	Cum	2,641.02	62	163,744
	(b) 3.0 m to 4.5 m	Cum	2,804.77	282	790,945
	(c) 4.50 m to 6.0 m	Cum	2,995.81	14	41,941
7	RCC (Reinforced concrete)	Cum	3,988.58	155	618,230
8	Constructing vent shafts	Nos.	16,000	10	160,000
9	Construction of scrapper manhole 2.43 m x1.53m				
	(a) up to depth 4.57m	Nos.	80,318	25	2,007,950
	(b) upto depth 9.14m	Nos.	14,189	9	127,701
10	Construction of manhole dia 1.22m				
	(a) upto depth 1.52m (type A1)	Nos.	14,148	14	198,072
	(b) upto depth 2.28m (type A2)	Nos.	5,417	2	10,834
11	Construction of manhole dia 1.52m				
	(a) upto depth 2.28m (type B1)	Nos.	19,352	96	1,857,792
	(b) upto depth 5.03m (type B2)	Nos.	6,088	209	1,272,392
	(c) upto depth 9.14m (type B3)	Nos.	6,747	42	283,374
12	Road restoration				
	Dismantling of tar road for laying sewer including shorting out and stacking serviceable	Sqm	1,250	7,878	9,847,500

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
	materials and disposal of unserviceable materials upto distance of 60 m and its rein statement after filling and proper compaction of trenches. Based on the nagar Mahapalika, P.W.D , VNS				
13	Shifting of electric and telephone cables				
	Provision for shifting and reinstatement of electric and telephone cable etc. during excavation and laying of sewer lines	LS			150,000
14	Shifting of temporary water supply lines				
	Provision for temporary shifting of existing sewers and water supply falling in the alignment of conveying main during excavation and the restoring utilities/ services to its original condition	LS			150,000
	Total cost				30,123,616 **(30,124,000)**

4.1.7 Need for the Scheme for Replacement of Broken / Choked Existing 60” Trunk Sewer from Golf Club (Near Panchghari Ghat) to Chhabile purwa

It has been observed that 60” trunk sewer carrying the wastewater load all the way from Phool Bagh to Chhabile Purwa at Jajmau via Cantonment is broken at Panchghari ghat and the line beyond this point is completely choked with solid wastes. Some of manholes are not even structurally fit and sound. All the wastewater load of 60” at present being discharged directly to river Ganga. Understanding the urgent need of pollution abatement of river Ganga it is felt and needed to lay a separate line of same dia and at same slope adjacent to the existing one

4.1.8 Master Plan Provisions

As such there is no such proposal of this scheme. However as per the Master Plan conditions of almost all the major existing sewers are to be surveyed and depending upon existing conditions different proposals to rectify them are to be suggested.

4.1.9 Survey Works Executed

Topographical survey was carried out throughout the proposed replacement stretch. The total distance of survey done is about 1 km.

Table 4.7 Capital Cost for the Replacement of Damaged 60" Existing Sewer

Sr.	Item	Unit	Rate (Rs.)	Quantity	Amount (Rs.)
1	Dismantling of existing 60” sewer and its replacement with 1600mm dia RCC NP-3 Pipe	m	8,000	1,000	8,000,000

4.1.10 Need for the Scheme for Tapping Facility of Bhagwatdas Ghat Nala and Pumping Station

Near Guptar ghat Nala an untapped nala called Bhagwatdas ghat nala exists. The flow of this nala is directly going to the river Ganga near the back of Ordnance factory. To control this polluting nala from the river Ganga nala intercepting is necessary.

4.1.11 Master Plan Provisions

The provision made in the Feasibility Report is in accordance with the Master Plan report

4.1.12 Survey Works Executed.

A reconnaissance survey was conducted from September 29th 2004 with the help of UP Jal Nigam officials. Topographical survey was carried out throughout the proposed alignment i.e. from proposed pumping station to the Bal Bhavan. Total length of alignment of survey done is 1.2 Km.

Around 0.5 ha of area was surveyed for the construction of pumping station to tap Bhagwatdas ghat nala.

(1) Geo Technical Survey

In order to access the soil profile of the pumping station site area 20-mt deep boreholes was bored.

Soil assessment report is as under:-

The top 6m soil is filled up in nature underlain by plastic soil, in the full exploration depth of 20 m, consisting of clayey silt of low plasticity (CI group). The N values range from 6 to 16 indicating medium to very stiff consistency. Small percentage of Kankar Chharri are met at various depths. The water table has been met at 1.75m below ground level.

4.1.13 Design Engineering Works

Design of interception and diversion of Bhagwatdas ghat nala is presented under this section, which falls in Sewerage District I of Kanpur city.

(1) Design Population and Flow

Catchment boundary was marked for Bhagwatdas ghat nala interceptor alignment as per Master Plan and contributing population and sewage flow for various years were calculated.

A summary table presenting the contributing population for year 2015 and 2030 along with the sewage conveyed is presented in Table No.4.8.

Table 4.8 Catchment Details for Bhagwatdas Ghat Nala Catchment

Bhagwatdas ghat nala catchment	Year 2015		Year 2030	
	Population Covered (Nos.)	Average Flow (mld)	Population Covered (Nos.)	Average Flow (mld)
	55,860	8.10	58,640	9.09

Table 4.9 Pipe Length for Rising Main for Bhagwatdas Ghat Nala

Sr.	Diameter, (mm)	Length of CI pipe (m)
1	400	1,210
	Total	1,210

The plan and profile of rising mains are presented in drawing no. KAP-PP-BD-1and 2.

4.1.14 Need for Tapping of Sisamau Nala to Parmat PS

Sisamau Nala is the largest nala of Kanpur city whose maximum flow is 138 mld. It has been proposed that under GAP (Ganga Action Plan), 100 mld of flow shall be taped at the upstream side and diverted to proposed Bingawan STP and the remaining 30 to 50 mld has already been taped at down stream side and provision to convey it through 36 inch line up to Parmat Pumping Station has been made. But as per the current ground reality, this scheme is not a success as the waste water of Sisamau nala is not reaching Parmat pumping station. There could be two reasons behind this. Either the carrying capacity of the existing sewer is less or there is a structural failure of the pipe. Provision of improper slope could also be one the reason.

4.1.15 Mater Plan Provisions

According to the Master Plan, new rising main has been proposed from the Parmat pumping station to Hudson School crossing to discharge in to a new relief sewer and also up gradation of existing pumping station has been proposed to meet the additional tapping of Sisamau nala.

4.1.16 Survey Works Executed.

A reconnaissance survey was conducted from September 29th 2004 with the help of UP Jal Nigam officials. Topographical survey was carried out along the proposed alignment. The total length of survey carried out is 1.6km.

4.1.17 Design for Sisamau Nala Tapping Facility

Catchment area for Sisamau nala area has been presented in Drawing No.KAN-CA-D1-2. The sewer is designed for year 2030.

The diameter and pipe class wise design summary of the Sisamau interception nala is presented in Table 4.11.

Table 4.10 Pipe Length for Details for Sisamau Nala Tapping

Sr.	**Diameter, (mm)**	**Length of NP3 pipe (m)**
1	1600	1,450
	Total	1,450

Table 4.11 Hydraulic Design for Sisamau Nala

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recomended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumulative length	UGL	DGL	UIL	DIL	Drop	Nalla bed	Remark
							M^3/sec	M^3/sec		M^3/sec	mm	1 in				m/sec	M^3/sec	M	M	(M)	(M)	(M)	(M)	(M)	(M)	
1	PRN_N2	PRN_N3	322581	0	322581	322581	0.579	0.579	2.25	1.302	1600	2000	0.69	0.68	0.94	0.88	1.30	200	200	115.16	113.84	110.00	109.90		111.51	Sisamau nalla
2	PRN_N3	PRN_N4	0	0	0	322581	0.000	0.579	2.25	1.302	1600	2000	0.69	0.68	0.94	0.88	1.30	200	400	113.84	114.72	109.90	109.80			
3	PRN_N4	PRN_N5	0	0	0	322581	0.000	0.579	2.25	1.302	1600	2000	0.69	0.68	0.94	0.88	1.30	150	550	114.72	115.65	109.80	109.73			
4	PRN_N5	PRN_N6	0	0	0	322581	0.000	0.579	2.25	1.302	1600	2000	0.69	0.68	0.94	0.88	1.30	250	800	115.65	115.77	109.73	109.60			
5	PRN_N6	PRN_N7	0	0	0	322581	0.000	0.579	2.25	1.302	1600	2000	0.69	0.68	0.94	0.88	1.30	100	900	115.77	115.36	109.60	109.55			
6	PRN_N7	PRN_N8	0	0	0	322581	0.000	0.579	2.25	1.302	1600	2000	0.69	0.68	0.94	0.88	1.30	300	1200	115.36	114.10	109.55	109.40			
7	PRN_N8	PRN_N9	0	0	0	322581	0.000	0.579	2.25	1.302	1600	2000	0.69	0.68	0.94	0.88	1.30	200	1400	114.10	112.96	109.40	109.30			
8	PRN_N9	PRN_N10	0	0	0	322581	0.000	0.579	2.25	1.302	1600	2000	0.69	0.68	0.94	0.88	1.30	50	1450	112.96	113.00	109.30	109.28			

4.1.18 Cost Estimates

Budgetary cost estimation of sewers are carried out based on schedule of rates and prevailing market rates and is tabulated below.

Table 4.12 Cost Estimation of Sisamau Nala Tapping Facility

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
1	Excavation				
(a)	Excavation for depth up to 1.5 m below G.L for laying Sewer manholes soil (earth, sand loam and clay) including cutting of joints pits ramming dressing) levelling, refilling of trenches in 20 cm layer watering and ramming the same including removal of surplus earth or other dismantled material upto a distance of 50 m. from the centre of trenches.				
	(a) 0 to 1.5 m depth	Cum	61	5,835	355,935
	(b) 1.5 to 3 m depth	Cum	75	5,313	398,475
	(c) 3 to 4.5 m depth	Cum	93	4,777	444,261
	(d) 4 .5to 6 m depth	Cum	107	3,281	351,067
	(e) 6.0 to 7.5 m depth	Cum	140	757	105,980
(b)	Same as item 1(a) but excavation in soil mixed with kankar and boulders				
	(a) 0 to 1.5 m depth	Cum	294	1,459	428,946
	(b) 1.5 to 3 m depth	Cum	338	1,329	449,202
	(c) 3 to 4.5 m depth	Cum	393	1,195	469,635
	(d) 4 .5to 6 m depth	Cum	452	821	371,092
	(e) 6.0 to 7.5 m depth	Cum	541	190	102,790
2	Shuttering				
(a)	Provide and fix close timbering in trenches for the depth up to 3 m below G.L consisting of 40 mm thick approved country wood plank for polling board 125 x 75 mm Indian Sal wood walers and 100 mm dia sal wood ballies for shutting at 1.50m C/C including removal after laying of sewers (both sides of trenches) will be taken as one side for the purpose of payment and measurement i.e. area equals to Length x depth of trenches, dismantled, timbering material will be the property of the Contractor. Details of cost for 30 m and 3 m deep trench i.e. 90 Sq M (M2) area of timbering				
	(a) 0 to 3 m	Sqm	176	2,175	382,800
	(b)3 to 6 m	Sqm	224	1,887	422,688
(b)	Same as item no.2 (a) but timbering left in trenches *(unused timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	1,392	115	160,080
(c)	Same as item no.2 (a) but timbering left in trenches *(used timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	584	77	44,968
3	Supply of following sizes of RCC spigotted and socketed non pressure pipes				
	(a) 1600 mm dia in 1.25 m length	m	7651.57	1,450	11,094,772
4	Laying jointing of RCC hume pipe				
	Carting following sizes of R.C.C hume pipe (NP3 Class socket /spigoted rubber ring jointed and specials from store to the work lowering the same in to the trenches in depth upto 1.5m below G.L true to alignment including excavation of earth below G.L invert level of pipe, cost of all jointing material, testing etc, complete but excluding excavation and refilling of trenches from ground level to the invert level of pipe.				
	Rate per meter at different depth				

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
	1600 mm dia pipe				
	(a) 3.0 – 4.50 m	m	2,135	410	875,350
	(b) 4.5 - 6.0 m	m	2,280	940	2,143,200
	(c) 6.0 - 7.5 m	m	2,484	100	248,400
5	Sand filling				
	Sand filling below ground level including supply of all materials labour T & P etc required for proper completion of work				
	(a) 3.0 m to 4.5 m	Cum	217.056	751.31	163,076
	(b) 4.50 m to 6.0 m	Cum	231.84	810.86	187,990
6	PCC (Plain cement concrete)				
	Cement concrete work in bedding below ground level with cement, coarse sand and 20 mm gauge approved stone ballast (1:2:4) including supply of all materials, labour, T & P etc, required for the proper completion of work.				
	(a) 4.50 m to 6.0 m	Cum	2,995.81	419	1,255,243
	(b) 6.0 m to 7.5 m	Cum	3,263.76	121	394,914
7	Constructing vent shafts	Nos.	16,000	3	48,000
8	Construction of scrapper manhole 2.43x1.53				
	Up to depth 4.57m	Nos.	80,318	13	1,044,134
	Upto depth 9.14m	Nos.	14,189	37	524,993
9	Construction of manhole dia 2.43 m x1.53 m				
	(a) Upto depth 4.57m (type D1)	Nos.	68,200	38	2,591,600
	(b) upto depth 9.14m (type D2)	Nos.	15,539	37	574,943
10	Road restoration				
	Dismantling of tar road for laying sewer including shorting out and stacking serviceable materials and disposal of unserviceable materials upto distance of 60 m and its rein statement after filling and proper compaction of trenches.	Sqm	1,250	5,81	6,351,250
11	Shifting of electric and telephone cables				
	Provision for shifting and reinstatement of electric and telephone cable etc. during excavation and laying of sewer lines	LS			100,000
12	Shifting of temporary water supply lines				
	Provision for temporary shifting of existing sewers and water supply falling in the alignment of conveying main during excavation and the restoring utilities/ services to its original condition	LS			100,000
	Total cost				32,185,784 **(32,186,000)**

4.1.19 Need for the Replacement of Existing Trunk Sewer from Rawatpur (I3a) to Hudson School Crossing (H) and Relief Trunk Sewer from Hudson School to Cantonment

It has been observed that (18” to 48”) Trunk sewer carrying the wastewater load all the way from Rawatpur railway station to Hudson school via Shani Dev temple (District I) is completely choked with solid wastes. Some of manholes are not even structurally fit and sound. Understanding the urgent need of pollution abatement of river Ganga it is felt and needed to lay a replacement sewer along the existing sewer alignment, i.e., from Rawatpur railway station to Hudson school.

To relieve the over load of existing of 60” sewer, a new relief sewer is proposed along the same alignment i.e. from Hudson school to Cantonment area.

4.1.20 Survey Works Executed

A reconnaissance survey was conducted from September 29th 2004 with the help of UP Jal Nigam officials. Topographical survey was carried out along the proposed alignment of replacement sewer and relief sewer from Rawatpur railway station to Hudson school and from Hudson school to Cantonment respectively. The total length surveyed is 9.6 Km.

(1) Geo Technical Survey

In order to access the soil profile of the alignment 10-mt deep boreholes was bored.

The soil strata up to 3.80 m are sandy silt of low plasticity (CL group) underlain by non plastic silty sand (SM group) up to 7 m. The soil from 7 m to full exploration depth of 10 m is silty clay of medium plasticity (CI group). The N value in plastic strata ranges from 10 to 18 indicating stiff and very stiff consistency. The water table has not been met.

4.1.21 Design Engineering Works

Designs of replacement and relief sewer from Rawatpur railway station to Hudson school and from Hudson school to 84” existing sewer at Cantonment respectively is presented under this section which fall in Sewerage District I of Kanpur city. As per the Master Plan there should be a provision of relief sewer from Hudson school to 78”but since the carrying capacity of 78” is lesser than the calculated flow, it has been decided to lay the relief sewer up to 84”existing sewer.

(1) Design Population and Flows

Catchment boundary was marked for Rawatpur railway station to Cantonment (84”) for replacement and relief sewer (I3a) to Hudson school crossing (H)], as per master plan and contributing population and sewage flow for various years were calculated.

A summary table presenting the contributing populations for year 2015 and 2030 along with the sewage conveyed is presented in Table 4.13.

Table 4.13 Catchment Details and Flows for Replacement of Existing Trunk Sewer from Rawatpur (I3a) to Hudson School Crossing (H) and Relief Trunk Sewer from Hudson School to Cantonment

Gravity Main	Year 2015		Year 2030	
	Population Covered (Nos.)	Average Flow (mld)	Population Covered (Nos.)	Average Flow (mld)
Rawatpur to 84”Existing sewer at Cantonment	357,334	51.81	419,029	64.95

(2) Design for Replacement of Sewer from Rawatpur (I3a) to Hudson School Crossing (H) and Relief Trunk Sewer from Hudson School to Cantonment

Designs of the replacement of sewer for from Rawatpur (I3a) to Hudson school crossing (H) and relief trunk sewer from Hudson school to Cantonment is presented in Table 4.14.

Catchment area of the replacement sewer has been presented in Drawing No.KAN-CA-D1. The sewer line is designed for year 2030.

Table 4.14 Details of Pipe for the Replacement of Existing Trunk Sewer from Rawatpur (I3a) to Hudson School Crossing (H) and Relief Trunk Sewer from Hudson School to Cantonment

Sr.	Diameter (mm)	Length of NP3 pipe for Replacement stretch (m)	Length of NP4 pipe for Relief stretch (m)
1	700	600	
2	800	1,350	
3	1200	550	
4	1400	1,050	
5	1600	1,800	
6	2200		4,516
	Total	5,350	4,516

4.1.22 Trenchless Options for Trunk Sewer

The selection of a trenchless option for the construction of a part of the proposed trunk sewer will avoid much of the disruption associated with traditional open cut construction. Trenchless construction involves access to the construction works at discrete points along the pipeline route rather than the disruption of a continuous corridor along the route with the requirement for temporary reinstatement and pavement patching. Site management of trenchless process involves the delivery of essential materials to these discrete intervention points in a timely fashion as opposed to the stringing out along the route of pipe and pipe bedding materials. Similarly the removal of spoil material can be managed in a timely fashion with the attendant avoidance of disruption. However it should be mentioned here that site management is the key to successful trenchless construction; a poorly organised site and bad practice can be immensely disruptive and damaging to the public interest causing damage to the perception of the implementing authority in a magnitude not dissimilar to open cut construction.

The selection of access points through specially constructed access shafts is important to minimize public disturbance, these access points can be 100-250 mm apart and the adjacent working areas if well managed can be minimized to the order of 30-70 square meters. Damage to adjacent buried infrastructure such as other utility services is always a risk. Careful survey and attention to local information can minimize this risk. Cooperation with other utility providers and the traffic authorities is an important contribution to successful installation. Careful selection of appropriate technology and materials will minimize future maintenance requirements. Trenchless methods can be expected to deliver better built quality for the most part, free from settlement and reinstatement problems.

There are a number of practical problems in the delivery of the trenchless option. Amongst the most important of these is the requirement for specialist product and equipment, much of which is not currently, available in India. Accordingly planning and selection place special burdens on the client, consultant and contractor. Sufficient time for detailed planning, discussion and programming is essential, detailed method statements and specifications are useful to the achievement of an understanding of all the key issues between the parties. This section of the report seeks to set out key issues for consideration to inform the selection process. The proposed trunk sewer involves both trenched and trenchless components; the section identified for trenchless construction (Table 4.15) is ideally suited being a deep sewer 3-10m to invert, located under a busy road where open trench construction would be enormously disruptive. Also the crossing of railway line could be possible with this method only .The open trench component involves a lot of special measures to avoid settling of the dug trenches in the case of deep sewer, like in this stretch. These special measures include uses of modern practice of closed sheeting or trench boxes to minimize trench width, which ensure worker safety.

Table 4.15 Trenchless Stretches

Sr.	Name of the stretch	Chainage	Length (m)	Physical Condition	Diameter (mm)	Depth of cover (m)
1	Near Mall road, Phoolbagh crossing, Rail way crossing	9,550-7,350	2,200	Rail way crossing and traffic	2200	6.85

Provision of trench-less technology is made at above-mentioned stretches where open cut excavation was found not feasible. The stretch of these locations where trench-less technology is to be provided is presented in Drawing No.KAN_TRENCH_LOC-1.

Open cut construction can be accomplished with reduced disruption using a trench box or drag box method so that regardless of the depth to formation, that is, below the pipe bedding the trench can be excavated safely without battering back the trench sides, to a minimum width. Close sheeting can also be used to control trench width and maintain safe working conditions but is more time consuming to install and requires closer supervision; the trench sheets are liable to damage and may be regarded as project consumables whereas trench or drag boxes can be regarded as capital items and maintained as such. Careful use of a trench box not only restricts the width of the trench and hence the work site but also the length of pipeline open at any one time to about 6-8 meters. Temporary reinstatement of the pavement after backfill and consolidation can minimize the length of road closure necessary.

With good site management the activity zone of the narrow trench construction outlined above can approximate to the scale of a pipe-jacking site, though the site footprint is larger and cannot be selected at optimum points along the pipeline for minimum disruption. Traditional trenching practice usually involves the temporary storage of excavated material and pipe bedding on site, although this inevitably makes the site area larger and more disruptive. Coordinated truck movement to ship in bedding and product pipe can minimize the area required.

4.1.23 Abstract of Cost Estimates: Trenchless Stretches

The Indian Society of Trenchless Technology Schedule lists rates for various diameter ranges installed by various techniques: the rate of Microtunnelling in soft soil is Rs. 73,000/m for the size range 600 – 900 mm diameter, Rs. 80,500/m for the size range 900 –1200 mm and Rs. 88,000/m for the size range 1200 – 1500 mm. These figures suggest a projection range up to 2400 mm of about Rs. 110,500/m. However, these schedules are for guidance only and the rates are not yet based on actual implementation in India. there is very limited experience of these techniques in India.

Such information as is available results from the experience of M/S AJECT, Michigan Engineers and Cherrington. AJECT have undertaken microtunnelling works in Mumbai; approximately, 4 km of trenchless work is carried out with at an average price of Rs. 80,000/m plus Rs. 11,000 for product pipe. Michigan has undertaken one project with an Iseki Uncle Mole in Calcutta and may use soft soil auger bores. Cherrington have installed 900 mm steel pipe in soft soil as sewer for Delhi Jal Board at about Rs. 55,000/m.

Interpolating between these data points would suggest a rate as shown in Table 4.16

Table 4.16 Diameter wise Unit Rate for Trenchless Technologies

Sr.	Diameter of sewer	Rate (Rs./m)
1	< = 1000 mm	73,000
2	1400 mm	96,800
3	1600 mm	100,000
4	1800 mm	107,800
6	2200 mm	116,050

Based on this unit cost, the total cost for trenchless stretch has been estimated and the same is presented in Table 4.17

Table 4.17 Abstract of Cost Estimates for Trenchless Technology Used for Relief Trunk Sewer of Sewerage District I

Sr.	Name of the stretch for	Length (m)	Diameter (mm)	Rate (Rs./m)	Amount (Rs.)
1	Near Mall road, fly over	2,200	2200	116,050	255,310,000
	Total				255,310,000

Table 4.18 Hydraulic Design for Replacement of Existing Trunk Sewer from Rawatpur (I3a) to Hudson School Crossing (H) and Relief Trunk Sewer from Hudson School to Cantonment

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recomended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumulative length	UGL	DGL	UIL	DIL	Drop	Nalla bed	Remark
							M^3/sec	LPD		M^3/sec	mm	1 in				m/sec	M^3/sec	M	M	(M)	(M)	(M)	(M)	(M)	(M)	
1	RC_N1	RC_N2	59699	0	59699	59699	0.107	9253345	2.25	0.241	700	900	0.78	0.74	0.97	0.78	0.24	300	300	124.48	123.76	121.48	121.15			
2	RC_N2	RC_N3	0	0	0	59699	0.000	9253345	2.25	0.241	700	900	0.78	0.74	0.97	0.78	0.24	300	600	123.76	123.81	121.05	120.71	0.1		
3	RC_N3	RC_N4	17687	0	17687	77386	0.032	11994830	2.25	0.312	800	1000	0.74	0.72	0.96	0.80	0.31	300	900	123.81	123.45	120.61	120.31	0.1		
4	RC_N4	RC_N5	0	0	0	77386	0.000	11994830	2.25	0.312	800	1000	0.74	0.72	0.96	0.80	0.31	300	1200	123.45	123.21	120.21	119.91	0.1		
5	RC_N5	RC_N6	7606	0	7606	84992	0.014	13173760	2.25	0.343	800	1000	0.82	0.76	0.99	0.82	0.34	350	1550	123.21	124.10	119.81	119.46	0.1		
6	RC_N6	RC_N7	0	0	0	84992	0.000	13173760	2.25	0.343	800	1000	0.82	0.76	0.99	0.82	0.34	400	1950	124.10	125.17	119.36	118.96	0.1		
7	RC_N7	RC_N8	5348	99539	104887	189879	0.188	29431245	2.25	0.766	1200	1500	0.76	0.73	0.97	0.86	0.77	250	2200	125.17	125.36	118.56	118.40	0.4		
8	RC_N8	RC_N9	0	0	0	189879	0.000	29431245	2.25	0.766	1200	1500	0.76	0.73	0.97	0.86	0.77	300	2500	125.36	123.78	118.30	118.10	0.1		
9	RC_N9	RC_N10	31085	0	31085	220964	0.056	34249420	2.25	0.892	1400	1800	0.64	0.65	0.92	0.83	0.89	100	2600	123.78	122.74	117.90	117.84	0.2		
10	RC_N10	RC_N11	8433	19503	27936	248900	0.050	38579500	2.25	1.005	1400	1800	0.72	0.70	0.95	0.86	1.00	150	2750	122.74	122.13	117.84	117.76	0		
11	RC_N11	RC_N12	0	0	0	248900	0.000	38579500	2.25	1.005	1400	1800	0.72	0.70	0.95	0.86	1.00	400	3150	122.13	121.57	117.56	117.34	0.2		
12	RC_N12	RC_N13	0	0	0	248900	0.000	38579500	2.25	1.005	1400	1800	0.72	0.70	0.95	0.86	1.00	250	3400	121.57	119.26	117.24	117.10	0.1		
13	RC_N13	RC_N14	780	10445	11225	260125	0.020	40319375	2.25	1.050	1400	1800	0.76	0.72	0.96	0.87	1.05	150	3550	119.26	119.02	117.10	117.01	0		
14	RC_N14	RC_N15	11844	4735	16579	276704	0.030	42889120	2.25	1.117	1600	2500	0.66	0.66	0.93	0.78	1.12	350	3900	119.02	123.20	116.81	116.67	0.2	116.48	Sisamau Nala
15	RC_N15	RC_N16	0	0	0	276704	0.000	42889120	2.25	1.117	1600	2500	0.66	0.66	0.93	0.78	1.12	400	4300	123.20	124.15	116.67	116.51	0		
16	RC_N16	RC_N17	0	0	0	276704	0.000	42889120	2.25	1.117	1600	2500	0.66	0.66	0.93	0.78	1.12	200	4500	124.15	124.07	116.51	116.43	0		
17	RC_N17	RC_N18	3877	7944	11821	288525	0.021	44721375	2.25	1.165	1600	2500	0.69	0.68	0.94	0.79	1.16	400	4900	124.07	123.19	116.33	116.17	0.1		
18	RC_N18	RC_N19	5640	0	5640	294165	0.010	45595575	2.25	1.187	1600	2500	0.71	0.69	0.95	0.79	1.19	250	5150	123.19	122.73	116.17	116.07	0		
19	RC_N19	RC_N20	0	0	0	294165	0.000	45595575	2.25	1.187	1600	2500	0.71	0.69	0.95	0.79	1.19	200	5350	122.73	121.83	116.07	115.99	0		
20	RC_N20	RC_N21	0	124864	124864	419029	0.803	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	350	5700	121.83	118.16	115.59	115.49	0.4		
21	RC_N21	RC_N22	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	300	6000	118.16	117.94	115.49	115.41	0		
22	RC_N22	RC_N23	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	300	6300	117.94	120.27	115.41	115.32	0		
23	RC_N23	RC_N24	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	250	6550	120.27	119.78	115.32	115.25	0		
24	RC_N24	RC_N25	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	200	6750	119.78	121.32	115.25	115.19	0		
25	RC_N25	RC_N26	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	400	7150	121.32	121.90	115.19	115.08	0		
26	RC_N26	RC_N27	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	200	7350	121.90	124.07	115.08	115.02	0		
27	RC_N27	RC_N28	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	300	7650	124.07	124.40	115.02	114.94	0		
28	RC_N28	RC_N29	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	250	7900	124.40	125.53	114.94	114.86	0		
29	RC_N29	RC_N30	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	350	8250	125.53	125.86	114.86	114.76	0		
30	RC_N30	RC_N31	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	450	8700	125.86	125.58	114.76	114.64	0		
31	RC_N31	RC_N32	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	250	8950	125.58	125.97	114.64	114.56	0		
32	RC_N32	RC_N33	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	400	9350	125.97	126.02	114.56	114.45	0		
33	RC_N33	RC_N34	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	200	9550	126.02	125.69	114.45	114.39	0		
34	RC_N34	RC_N35	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	90	9640	125.69	125.69	114.29	114.27	0.1		
35	RC_N35	RC_N36	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	98	9738	125.69	125.85	114.27	114.24	0		
36	RC_N36	RC_N37	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	48	9786	125.85	125.63	114.24	114.23	0		
37	RC_N37	RC_N38	0	0	0	419029	0.000	114949495	2.00	2.661	2200	3500	0.80	0.75	0.98	0.86	2.66	80	9866	125.63	125.01	114.23	114.20	0		

4.1.24 Cost Estimates

Budgetary cost estimation of the sewers was carried out based on schedule of rates and prevailing market rates and is tabulated below.

Table 4.19 Cost Estimation for Replacement of Existing Trunk Sewer from Rawatpur (I3a) to Hudson School Crossing (H) and Relief Trunk Sewer from Hudson School to Cantonment

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
1	Excavation				
(a)	Excavation for depth up to 1.5 m below G.L for laying Sewer, manholes (earth, sand loam and clay) including cutting of joints pits ramming dressing) levelling, refilling of trenches in 20 cm layer watering and ramming the same including removal of surplus earth or other dismantled material upto a distance of 50 m. from the centre of trenches.				
	(a) 0 to 1.5 m depth	Cum	61	43,130	2,630,930
	(b) 1.5 to 3 m depth	Cum	75	39,481	2,961,075
	(c) 3 to 4.5 m depth	Cum	93	31,811	2,958,423
	(d) 4 .5to 6 m depth	Cum	107	25,820	2,762,740
	(e) 6.0 to 7.5 m depth	Cum	140	19,934	2,790,760
	(f) 7.5m to 9.0 m depth	Cum	184	12,202	2,245,168
	(g) 9.0m to 10.5 m depth	Cum	240	9,505	2,281,200
	(h) 10.5m to 12.0 m depth	Cum	312	6,771	2,112,552
	(i) 12.0m to 13.5 m depth	Cum	406	688	279,328
(b)	Same as item 1(a) but excavation in soil mixed with kankar and boulders				
	(a) 0 to 1.5 m depth	Cum	294	10,783	3,170,202
	(b) 1.5 to 3 m depth	Cum	338	9,871	3,336,398
	(c) 3 to 4.5 m depth	Cum	393	7,953	3,125,529
	(d) 4 .5to 6 m depth	Cum	452	6,455	2,917,660
	(e) 6.0 to 7.5 m depth	Cum	541	4,984	2,696,344
	(f) 7.5m to 9.0 m depth	Cum	663	3,051	2,022,813
	(g) 9.0m to 10.5 m depth	Cum	812.51	2,377	1,931,341
	(h) 10.5m to 12.0 m depth	Cum	995.74	1,693	1,685,788
	(i) 12.0m to 13.5 m depth	Cum	1,005.70	172	172,980
2	Shuttering				
(a)	Provide and fix close timbering in trenches for the depth up to 3 m o 3m below G.L consisting of 40 mm thick approved country wood plank for polling board 125 x 75 mm Indian Sal wood walers and 100 mm dia sal wood ballies for shutting at 1.50m C/C including removal after laying of sewers (both sides of trenches) will be taken as one side for the purpose of payment and measurement i.e. area equals to Length x depth of trenches, Dismantled, timbering material will be the property of the Contractor. Details of cost for 30 m and 3 m deep trench i.e. 90 sqm area of timbering				
	(a) 0 to 3 m	Sqm	176	14,763	2,598,288
	(b) 3 to 6 m	Sqm	224	10,737	2,405,088
(b)	Same as item no.2 (a) but timbering left in trenches *(unused timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	1,392	3,619	5,037,648
	(b) 9 to 12 m	Sqm	1,600	1,875	3,000,000
	(c) 12 to 15 m	Sqm	1,840	84	154,560
(c)	Same as item no.2 (a) but timbering left in trenches *(used timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	584	2,413	1,409,192
	(b) 9 to 12 m	Sqm	670	1,250	837,500
	(c) 12 to 15 m	Sqm	770	56	43,120
3	Supply of following sizes of RCC spigotted and				

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
	socketed non pressure pipes				
	(a) 700 mm dia in 1.25 m length	m	1,788.71	600	1,073,226
	(b) 800 mm dia in 1.25 m length	m	2,311.75	1,350	3,120,856
	(c) 1200 mm dia in 1.25 m length	m	4,507.84	550	2,479,311
	(d) 1400 mm dia in 1.25 m length	m	5,926.83	1,050	6,223,170
	(e) 1600 mm dia in 1.25 m length	m	7,651.57	1,800	13,772,820
	(f) 2200 mm dia in 1.25 m length	m	16,044.50	4,516	72,456,962
4	Laying jointing of RCC hume pipe				
	Carting following sizes of R.C.C Hume pipe (NP3 Class Socket /spigoted rubber ring jointed and specials from store to the work lowering the same in to the trenches in depth upto 1.5m below G.L true to alignment including excavation of earth below G.L invert level of pipe, cost of all jointing material, testing etc, complete but excluding excavation and refilling of trenches from ground level to the invert level of pipe.				
	Rate per meter at different depth				
	700 mm dia pipe				
	(b) 1.5 - 3.00 m	m	560	480	268,800
	(c) 3.0 - 4.50 m	m	595	120	71,400
	800 mm dia pipe				
	(a)3.0 - 4.50 m	m	747	880	657,360
	(b) 4.5 - 6.0 m	m	797	390	310,830
	(c) 6.0 - 7.5 m	m	869	80	69,520
	1200 mm dia pipe				
	(d) 6.0 - 7.5 m	m	1,625	460	747,500
	(e) 7.5 - 9.0 m	m	1,805	90	162,450
	1400 mm dia pipe				
	(a)1.5 - 3.00 m	m	1,668	250	417,000
	(b)3.0 - 4.50 m	m	1,771	230	407,330
	(c) 4.5 - 6.0 m	m	1,891	570	1,077,870
	1600 mm dia pipe				
	(a)1.5 - 3.00 m	m	2,010	70	140,700
	(b)3.0 - 4.50 m	m	2,135	105	224,175
	(c) 4.5 - 6.0 m	m	2,280	205	467,400
	(d) 6.0 - 7.5 m	m	2,484	940	2,334,960
	(e) 7.5 - 9.0 m	m	2,760	480	1,324,800
	2200 mm dia pipe				
	(a)1.5 - 3.00 m	m	3,319	490	1,626,310
	(b)3.0 - 4.50 m	m	3,524	225	792,900
	(c) 4.5 - 6.0 m	m	3,764	575	2,164,300
	(d) 6.0 - 7.5 m	m	4,101	550	2,255,550
	(e) 7.5 - 9.0 m	m	4,556	120	546,720
	(f) 9.0 - 10.50m	m	5,101	540	2,754,540
	(g) 10.50- 12.0 m	m	5,767	2,016	11,626,272
5	Sand filling				
	Sand filling below ground level including supply of all materials labour T & P etc required for proper completion of work				
	(a) 1.5 m to 3.0 m	Cum	204.384	1,114	227,684
	(b) 3.0 m to 4.5 m	Cum	217.056	2,326	504,872
	(c) 4.50 m to 6.0 m	Cum	231.84	1,957	453,711
	(d) 6.0 m to 7.5 m	Cum	252.576	150	37,886
	(f) 9.0 m- 10.50m	Cum	314.208	756	237,541
	(g) 10.50m- 12.0 m	Cum	355.2	7,613	2,704,138
6	PCC (Plain Cement Concrete)				
	Cement concrete work in bedding below ground level with cement, coarse sand and 20 mm gauge approved stone ballast (1:2:4) including supply of all materials, labour, T & P etc, required for the proper completion of work.				
	(a) 1.5 m to 3.0 m	Cum	2,641.02	167	441,051

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
	(b) 3.0 m to 4.5 m	Cum	2,804.77	307	861,065
	(c) 4.50 m to 6.0 m	Cum	2,995.81	378	1,132,415
	(d) 6.0 m to 7.5 m	Cum	3,263.76	1,764	5,757,265
	(e) 7.5 m to 9.0 m	Cum	3,625.98	529	1,918,144
7	RCC	Cum	3,988.58	8,777	35,007,764
8	Constructing vent shafts	Nos.	16,000	20	320,000
9	Construction of scrapper manhole 2.43m x1.53 m				
	(a) up to depth 4.57m	Nos.	80,318	78	6,264,804
	(b) upto depth 9.14m	Nos.	14,189	178	2,525,642
	(c) upto depth 14.0 m	Nos.	22,040	42	925,680
10	Construction of manhole dia 1.52m				
	(a) upto depth 2.28m (type B1)	Nos.	19,352	52	1,006,304
	(b) upto depth 5.03m (type B2)	Nos.	6,088	80	487,040
	(c) upto depth 9.14m (type B3)	Nos.	6,747	13	87,711
11	Construction of manhole dia 1.82m				
	(a) upto depth 2.28m (type C1)	Nos.	26,914	15	403,710
	(b) upto depth 5.03m (type C2)	Nos.	8,715	49	427,035
	(c) upto depth 9.14m (type C3)	Nos.	11,668	23	268,364
12	Construction of manhole dia 2.43 mx1.53 m				
	(a) upto depth 4.57m (type D1)	Nos.	68,200	197	13,435,400
	(b) upto depth 9.14m (type D2)	Nos.	15,539	511	7,940,429
	(c) upto depth 14.00 m(type D3)	Nos.	2,2136	128	2,833,408
13	Road restoration				
	Dismantling of tar road for laying sewer including shorting out and stacking serviceable materials and disposal of unserviceable materials upto distance of 60 m and its rein statement after filling and proper compaction of trenches. Based on the nagar Mahapalika, P.W.D, VNS	Sqm	1,250	37,368	46,710,000
14	Shifting of electric and telephone cables				
	Provision for shifting and reinstatement of electric and telephone cable etc. during excavation and laying of sewer lines	LS			250,000
15	Shifting of temporary water supply lines				
	Provision for temporary shifting of existing sewers and water supply falling in the alignment of conveying main during excavation and the restoring utilities/ services to its original condition	LS			250,000
16	Provision of trenchless technology (Ref. Table-4.15)	As per Table 4.17			255,310,000
	Total cost				575,870,723 **(575,871,000)**

4.2 SEWERAGE DISTRICT II

Sewerage District II is bounded by the city district of District I to the north, Kanpur Jhansi railway line to the west, and Pandu river to the south. The eastern boundary is surrounded by Hamirpur road. Priority projects defined under Master Plan for this Sewerage District II include,

1) Duplication and replacement of existing sewer from Kidwai Nagar Police Line to Munshi purwa pumping station

Designs and cost estimates for duplication and replacement of existing sewer from Kidwai Nagar PS to Munshi purwa pumping station is presented in this section.

4.2.1 Need for the Scheme for Duplication and Replacement of Existing Sewer from Kidwai Nagar Police Station to Munshi Purwa Pumping Station

After the detailed study, it has been observed that the newly laid sewer line from. Kidwai nagar police station to point Z (near to Munshi purwa pumping station) is not carrying the wastewater load of the catchment area. And also the further old existing sewer line from point Z to A''' has structurally failed. Hence to convey the desired wastewater load, a duplicate line is necessary to be laid along the existing sewer line from Z2' to Z and further the existing line from Z to A' (Near -Munshi purwa pumping station) is needed to be replaced.

4.2.2 Master Plan Provisions

As per the Master Plan, stretch for the proposed sewer is from S-13 to S-12 where as the stretch for the replacement of old sewer is from Z'' to A '.

4.2.3 Survey Works Executed

MWH has carried out following survey works on this alignment.

- Reconnaissance Survey
- Topographical Survey
- Geo Technical Survey

(1) Reconnaissance

A reconnaissance survey was conducted from September 29th 2004 with the help of UP Jal Nigam officials. Topographical survey was carried out along the proposed alignment. The total length of survey is 3.8 km.

(2) Geo Technical Survey

In order to access the soil profile of the alignment 10-mt deep boreholes was bored.

Soil assessment report:

The strata up to 1 m is filled up in nature. The under laying soil strata is plastic in nature consisting of sandy silt of low plasticity (ML group), clayey silt of low plasticity (CL group) up to full exploration depth of 10m.The N values in plastic strata are 9 to 13 indicating stiff consistency. The water table has not been met in the borehole.

4.2.4 Design Engineering Works

Designs for duplicate and replacement sewer from Kidwai Nagar to Munshi purwa pumping station area is presented under this section, which falls in Sewerage District II of Kanpur city.

(1) Design Population and Flows

Catchment boundary was marked for duplicate and replacement sewer from Kidwai Nagar to Munshi purwa pumping station alignment as per Master Plan and contributing population and sewage flow for various years were calculated.

A summary table presenting the contributing population for year 2015 and 2030 along with the sewage conveyed is presented in Table No.4.20

Table 4.20 Catchment Details of Duplication and Replacement of Existing Sewer from Kidwai Nagar to Munshi Purwa PS

Gravity Sewer	Year 2015		Year 2030	
	Population Covered (Nos.)	Average Flow (mld)	Population Covered (Nos.)	Average Flow (mld)
Duplication and replacement of Existing Sewer from Kidwai Nagar to Munshi Purwa Pumping station	480,939	69.74	531,353	82.36

(1) Design for Duplication and Replacement of Existing Sewer from Kidwai Nagar to Munshi Purwa Pumping Station

Designs of duplication and replacement of existing sewer from Kidwai Nagar to Munshi purwa pumping station area is presented in Table 4.21.

Catchment area of the duplication and replacement existing sewer from Kidwai Nagar to Munshi purwa pumping station area has been presented in Drawing No.KAN-CA-D2-1. The sewer line is designed for year 2030.

Table 4.21 Pipe Detail for the Duplication and Replacement of Existing Sewer from Kidwai Nagar to Munshi Purwa Pumping Station

Sr.	Diameter (mm)	Length of NP3 pipe- for duplication (m)	Length of NP4 pipe - for replacement (m)
1	700	1,550	
2	900	600	
3	1000	500	
4	1100	275	
5	1600	425	
6	1800		250
7	2000		200
	Total	3,350	450

Table 4.22 Hydraulic Design for sewer from Kidwai Nagar to Munshipurwa Pumping station
(Duplicate and Replacement of Existing Sewer from Kidwai Nagar to Munshi Purwa PS)

From	To	Popln_ Line	Popln_B ranch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow (Qa)	Design Peak Flow	Dia Recom ended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumula tive length	UGL	DGL	UIL	DIL	Drop
						M3/sec	M3/sec		LPS	M3/sec	mm	1 in				m/sec	M3/sec	M	M	(M)	(M)	(M)	(M)	(M)
KM_N1	KM_N5	34705	73226	107931	107931	0.194	0.194	2.25	435.66	0.240	700	1000	0.82	0.76	0.99	0.75	0.24	750	750	122.90	124.50	119.90	119.15	
KM_N5	KM_N10	28185	15906.8	44091	152022	0.079	0.273	2.25	613.63	0.196	700	1000	0.67	0.67	0.93	0.71	0.20	800	1550	124.50	124.56	119.05	118.25	0.1
KM_N10	KM_N15	73431	15945.6	89377	241399	0.160	0.433	2.25	974.40	0.487	900	1000	0.85	0.78	1.00	0.90	0.49	600	2150	124.56	123.60	118.05	117.45	0.2
KM_N15	KM_N20	29218	0	29218	270617	0.052	0.485	2.25	1092.33	0.601	1000	1200	0.87	0.79	1.01	0.89	0.60	500	2650	123.60	123.56	117.35	116.93	0.1
KM_N20	KM_N25	16183	0	16183	286800	0.029	0.515	2.25	1157.66	0.695	1100	1200	0.78	0.74	0.97	0.92	0.69	275	2925	123.56	124.00	116.83	116.60	0.1
KM_N25	KM_N30	26044	65037.5	91082	377881	0.163	0.678	2.25	1525.30	1.525	1600	2000	0.81	0.76	0.99	0.92	1.53	425	3350	124.00	123.89	116.10	115.89	0.5
KM_N30	KM_N35	12644	52170.4	64814	442696	0.116	0.794	2.25	1786.92	1.787	1800	2500	0.78	0.74	0.97	0.88	1.79	250	3600	123.89	125.92	115.69	115.59	0.2
KM_N35	KM_PS	16242	72415.4	88657	531353	0.160	0.954	2.25	2147.09	2.147	2000	3000	0.77	0.73	0.97	0.86	2.15	200	3800	125.92	124.62	115.39	115.33	0.2

4.2.5 Cost Estimates

Budgetary cost estimation for sewer was carried out based on schedule of rates and prevailing market rates and is tabulated below.

Table 4.23 Cost Estimation for Duplicate and Replacement of Existing Sewer from Kidwai Nagar to Munshi Purwa Pumping station

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
1	Excavation, rock cutting				
(a)	Excavation for depth up to 1.5 m below G.L for laying Sewer manholes ordinary soil (earth, sand loam and clay) including cutting of joints pits ramming dressing) levelling, refilling of trenches in 20 cm layer watering and ramming the same including removal of surplus earth or other dismantled material upto a distance of 50 m. from the centre of trenches.				
	(a) 0 to 1.5 m depth	Cum	61	13,089	798,429
	(b) 1.5 to 3 m depth	Cum	75	11,874	890,550
	(c) 3 to 4.5 m depth	Cum	93	9,550	888,150
	(d) 4 .5to 6 m depth	Cum	107	7,947	850,329
	(e) 6.0 to 7.5 m depth	Cum	140	5,004	700,560
	(f) 7.5m to 9.0 m depth	Cum	184	2,498	459,632
	(g) 9.0m to 10.5 m depth	Cum	240	736	176,640
	(h) 10.5m to 12.00 m depth	Cum	312	385	120,120
(b)	Same as item 1(a) but excavation in soil mixed with kankar and boulders				
	(a) 0 to 1.5 m depth	Cum	294	3,273	962,262
	(b) 1.5 to 3 m depth	Cum	338	2,969	1,003,522
	(c) 3 to 4.5 m depth	Cum	393	2,388	938,484
	(d) 4 .5to 6 m depth	Cum	452	1,987	898,124
	(e) 6.0 to 7.5 m depth	Cum	541	1,251	676,791
	(f) 7.5m to 9.0 m depth	Cum	663	625	414,375
	(g) 9.0m to 10.5 m depth	Cum	812.51	184	149,502
	(h) 10.5m to 12.00 m depth	Cum	995.74	97	96,587
2	Shuttering				
(a)	Provide and fix close timbering in trenches for the depth up to 3 m o 3m below G.L consisting of 40 mm thick approved country wood plank for polling board 125 x 75 mm Indian Sal wood walers and 100 mm dia sal wood ballies for shutting at 1.50m C/C including removal after laying of sewers (both sides of trenches) will be taken as one side for the purpose of payment and measurement i.e. area equals to Length x depth of trenches, Dismantled, timbering material will be the property of the Contractor. Details of cost for 30 m and 3 m deep trench i.e. 90 Sq M (M2) area of timbering				
	(a) 0 to 3 m	Sqm	176	5,700	1,003,200
	(b) 3 to 6 m	Sqm	224	4,623	1,035,552
(b)	Same as item no.2 (a) but timbering left in trenches *(unused timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	1,392	1,109	1,543,728
	(b) to 12 m	Sqm	1,600	140	224,000
(c)	Same as item no.2 (a) but timbering left in trenches *(used timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	584	740	432,160
	(b) 9 to 12 m	Sqm	670	94	62,980
3	Supply of following sizes of RCC spigotted and socketed non pressure pipes				
	(a) 700 mm dia in 1.25 m length	m	1,788.71	1,550	2,772,501

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
	(b) 900 mm dia in 1.25 m length	m	2,784.76	600	1,670,858
	(c) 1000 mm dia in 1.25 m length	m	3,267.67	500	1,633,837
	(d) 1100 mm dia in 1.25 m length	m	3,825.78	275	1,052,090
	(e) 1600 mm dia in 1.25 m length	m	7,651.57	425	3,251,916
	(f) 1800 mm dia in 1.25 m length	m	10,034.84	250	2,508,710
	(g) 2000 mm dia in 1.25 m length	m	12,889.40	20	2,577,880
4	Laying jointing of RCC hume pipe				
	Carting following sizes of R.C.C Hume pipe (NP3 Class Socket /spigoted rubber ring jointed and specials from store to the work lowering the same in to the trenches in depth upto 1.5m below G.L true to alignment including excavation of earth below G.L invert level of pipe, cost of all jointing material, testing etc, complete but excluding excavation and refilling of trenches from ground level to the invert level of pipe.				
	Rate per meter at different depth				
	700 mm dia pipe				
	(a) 3.0 - 4.50 m	m	595	375	223,125
	(b) 4.5 - 6.0 m	m	636	775	492,900
	(c) 6.0 - 7.5 m	m	692	400	276,800
	900 mm dia pipe				
	(a) 6.0 - 7.5 m	m	1,021	600	612,600
	1000 mm dia pipe				
	(a) 6.0 - 7.5 m	m	1,198	500	599,000
	1100 mm dia pipe				
	(a) 6.0 - 7.5 m	m	1,409	275	387,475
	1600 mm dia pipe				
	(a) 7.5 - 9.0 m	m	2,760	425	1,173,000
	1800 mm dia pipe				
	(a) 9.0 - 10.50m	m	3,691	150	553,650
	(b) 10.50- 12.0 m	m	4,172	100	417,200
	2000 mm dia pipe				
	(a) 9.0 - 10.50m	m	4,362	160	697,920
	(b) 10.50- 12.0 m	m	4,931	40	197,240
5	Sand filling				
	Sand filling below ground level including supply of all materials labour T & P etc required for proper completion of work				
	(a) 9.0 m- 10.50m	Cum	314.208	512	160,874
	(b) 10.50m- 12.0 m	Cum	355.2	128	45,466
6	PCC (Plain cement concrete)				
	Cement concrete work in bedding below ground level with cement, coarse sand and 20 mm gauge approved stone ballast (1:2:4) including supply of all materials, labour, T & P etc, required for the proper completion of work.				
	(a) 3.0 m to 4.5 m	Cum	2,804.77	89	249,625
	(b) 4.50 m to 6.0 m	Cum	2,995.81	183	548,233
	(c) 6.0 m to 7.5 m	Cum	3,263.76	631	2,059,430
	(d) 7.5 m to 9.0 m	Cum	3,625.98	478	1,733,219
	(e) 9.0 m- 10.50m	Cum	4,060.16	126	511,580
7	RCC (Reinforced cement concrete)	Cum	3,988.58	640	2,552,691
8	Constructing vent shafts	Nos.	16,000	8	128,000
9	Construction of scrapper manhole 2.43x1.53				
	(a) up to depth 4.57m	Nos.	80,318	28	2,248,904
	(b) Upto depth 9.14m	Nos.	14,189	65	922,285
	(c) upto depth 14.0 m	Nos.	22,040	6	132,240
10	Construction of manhole dia 1.52m				
	(a) upto depth 2.28m (type B1)	Nos.	19,352	57	1,103,064
	(b) upto depth 5.03m (type B2)	Nos.	6,088	157	955,816
	(c) upto depth 9.14m (type B3)	Nos.	6,747	57	384,579

Sr.	**Items**	**Units**	**Rate (Rs.)**	**Quantity**	**Amount (Rs.)**
11	Construction of manhole dia 1.82m				
	(a) upto depth 2.28m (type C1)	Nos.	26,914	21	565,194
	(b) upto depth 5.03m (type C2)	Nos.	8,715	58	505,470
	(c) upto depth 9.14m (type C3)	Nos.	11,668	40	466,720
12	Construction of manhole dia 2.43 mx1.53 m				
	(a) upto depth 4.57m (type C1)	Nos.	68,200	24	1,636,800
	(b) upto depth 9.14m (type C2)	Nos.	15,539	96	1,491,744
	(c) upto depth 14.00 m(type C3)	Nos.	22,136	16	354,176
13	Road restoration				
	Dismantling of tar road for laying sewer including shorting out and stacking serviceable materials and disposal of unserviceable materials upto distance of 60 m and its rein statement after filling and proper compaction of trenches.	Sqm	1,250	11,306	14,132,500
14	Shifting of electric and telephone cables				
	Provision for shifting and reinstatement of electric and telephone cable etc. during excavation and laying of sewer lines	LS			150,000
15	Shifting of temporary water supply lines				
	Provision for temporary shifting of existing sewers and water supply falling in the alignment of conveying main during excavation and the restoring utilities/ services to its original condition	LS			150,000
	Total cost				68,612,988 **(68,613,000)**

4.3 SEWERAGE DISTRICT III

Sewerage District III is bounded by the Pandu river to the south, Kanpur Jhansi railway line to the east and development Master Plan boundaries to the west and north. Important localities of this district are as follows:-

To the south of Grand Trunk road the fertilizer factory, Armapur state, Panki power generating station, Indian institute of technology are located

To the north of Grand Trunk road, Lakhanpur area, Kanpur University and HBIT (Hercourt Butler Technological Institute) are located.

Priority projects defined under Master Plan for this District III include,

1) Installation of proposed trunk sewers i.e. from Makrikhera nala to Panka Bahadur Nagar.
2) Renovation of existing Lakhanpur pumping station
3) Panki pumping station near upper Ganga canal
4) Panka MPS
5) Panka Bahadur Nagar sewage treatment plant for District III

4.4 TRENCHLESS OPTIONS FOR TRUNK SEWER IN DISTRICT III

Table 4.24 Trenchless Stretches for Sewerage District III

Sr.	Name of the stretch	Chainage	Length (m)	Physical Condition	Diameter (mm)	Depth of cover (m)
1	Near Kalyanpur Railway crossing	4,260-4,590	330	Rail way crossing	1600	6.50
2	Near Tambeshwar temple railway crossing-1	8,140-8,190	50	Rail way crossing	1800	4.35
3	Near Tambeshwar temple railway crossing-2	8,350-8,400	50	Rail way crossing	1800	4.35
4	Railway crossing near Panki Railway station	10,750-10,860	110	Rail way crossing	1800	5.50
5	Bypass fly over near Panki road	11,310-11,410	100	Heavy traffic	1800	3.10

Provision of trench-less technology is made at above-mentioned stretches where open cut excavation was found not feasible. The stretch of these locations where trench-less technology is provided is presented in Drawing No.KAN_TRENCH_LOC-1.

Table 4.25 Diameter wise Unit Rate for Trenchless Technology

Sr.	Diameter of sewer	Rate (Rs./meter)
1	< = 1000 mm	73,000
2	1400 mm	96,800
3	1600 mm	100,000
4	1800 mm	107,800
5	2200 mm	116,050

Based on this unit cost, the total cost for trenchless technology has been estimated and the same is presented in Table 4.26.

Table 4.26 Abstract of Cost Estimates for Trenchless Technology Used for Trunk Sewer of District III

Sr.	Name of the stretch for	Length (m)	Diameter (mm)	Rate (Rs./m)	Amount (Rs.)
1	Near Kalyanpur railway crossing	330	1600	100,000	33,000,000
2	Near Tambeshwar temple crossing-1	50	1800	107,800	5,390,000
3	Near Tambeshwar temple crossing-2	50	1800	107,800	5,390,000
4	Railway crossing near Panki railway station	110	1800	107,800	11,858,000
5	Bypass fly over near Panki Road	100	1800	107,800	10,780,000
	Total (District III)				66,418,000

4.4.1 Need for the Scheme for Installation of Proposed Trunk Sewer in District III

The untapped Makrikhera nala, covering the area of Lakhanpur is directly going to the river Ganga. There is no integrated sewerage system in this area. In order to arrest this nala directly joining the river

Ganga a trunk sewer is proposed from Lakhanpur area, covering the Kanpur Development Authority area near Lakhanpur, Kalyanpur Bithoor road, Kalyanpur Panki road Armapur estate and Panki power generating station.

4.4.2 Master Plan Provisions

(1) Renovation of Existing Lakhanpur Pumping Station

This pumping station was commissioned in 1982. However, it is not working now because of the reasons like clogging of incoming pipes, some where even breakage of incoming pipes and tremendous increase in the population contributing more waste water generation than the expectation. Damaged pumps and motors are also one of the reasons. Therefore the pumping station needs to be rehabilitated. The pumping station collects flow from a colony developed on the north side of the Grand Trunk (GT) road. At present, wastewater from this colony flows through natural drains up to the river Ganga The Master Plan proposes to rehabilitate this station. Sewage will be pumped to a new trunk sewer and conveyed to proposed Panki SP and further to the treatment plant via main pumping station at Panka near Pandu river.

(2) Panki Pumping Station

The Master Plan proposes the Panki pumping station on the northern side of the branch of the Upper Ganga canal. It is proposed to lay the rising mains across the canal. The rising main will carry sewage to a gravity sewer – starting from the other side of canal. The pumping station will cater to the flows of 80 mld in the year 2015 and 126 mld in the year 2030. For crossing the canal called Panki canal construction of a bridge is suggested.

(3) Panka Bahadur Nagar Sewage Treatment Plant

Panka Bahadur Nagar Sewage Treatment plant is proposed to treat sewage generated in the Sewerage District III, covering the area of Armapur estate, Fertilizer factory, Panki power generating station, Indian Institute of Technology, Lakhanpur area and Kanpur University. The anticipated flow in the year 2030 for this STP is 199 mld.

The scheme recommended for this STP in the Master Plan is UASB plus post treatment with aerated lagoons.

Note: - For further details of different Pumping Stations and Treatment Plants please refer Section No.5 and No.6 respectively.
Here in this chapter only the sewerage part is discussed.

4.4.3 Survey Works Executed

MWH has carried out following survey works on the alignment of the proposed Trunk sewer.

- Reconnaissance Survey
- Topographical Survey
- Geo Technical Survey

(1) Reconnaissance Survey

A reconnaissance survey was conducted from September 29th 2004 with the help of UP Jal Nigam officials.

Topographical survey was carried out along the proposed alignment. The total length of survey is 12.420 km.

(2) Geo Technical Survey

Four bore holes each of 10 m depth were bored along the proposed trunk sewer alignment. The results of the soil investigation are presented as under.

Soil Assessment Report:-

The top 7.60m soil is plastic in nature consisting of sandy silt of very low plasticity (ML group) and clayey silt of low plasticity (CL group) with N value of 8 to 18 indicating stiff and very stiff consistency. Small percentage of Kankar Chharri is also present at few depths. Through out the depth of borehole no water table was met.

4.4.4 Design Engineering Works

Designs of proposed trunk sewer from Makrikhera nala to Panka Bahadur Nagar STP is presented under this section, which fall in Sewerage District III of Kanpur city.

(1) Design Population and Flow

Catchment boundary was marked for trunk sewer for Makrikhera nala to Panka Bahadur Nagar STP area as per Master Plan and contributing population and sewage flow for various years were calculated.
A summary table presenting the contributing population for year 2015 and 2030 along with the sewage conveyed is presented in Table No.4.27

Table 4.27 Catchment Details of Trunk Sewer from Makrikhera Nala to Panka Bahadur Nagar STP

Gravity Sewer	Year 2015		Year 2030	
	Population Covered (Nos.)	Average Flow (mld)	Population Covered (Nos.)	Average Flow (mld)
Trunk sewer from Makrikhera nala to Panka Bahadur Nagar STP				
Lakhanpur Pumping Station	122,432	17.75	217,978	33.79
Panki Pumping Station	493,445	71.55	714,189	110.70
Panka MPS	754,701	109.43	1,199,315	185.89

(1) Design of Sewer for Trunk Sewer from Makrikhera Nala to Panka Bahadur Nagar STP

Designs of the trunk sewer from Makrikhera nala to Panka Bahadur Nagar STP is presented in Table 4.28.

Catchment area of the trunk sewer from Makrikhera nala to Panka Bahadur Nagar STP has been presented in Drawing No. KAN- CA-D3-1. The sewer line is designed for year 2030.

Table 4.28 Pipe Length Details for Makrikhera Nala to Panka STP

(m)

Sr.	Diameter (mm)	To Lakhanpur PS	To Panki PS	To Panka STP	Remarks
1	600	1,485			NP3
2	900	965			
3	1200		1,200		
4	1600		1,470		
5	1800		1,470	6,660	NP4
6	2000		790	280	
	Total	2,450	4,930	6,940	

Table 4.29 hydraulic Design of Trunk Sewer from Makrikhera Nala to Panka Bahadur Nagar STP

Hydraulic Design for sewer from Makarikhera to Lakhanpur Pumping Station

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recom ended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumul ative length	UGL	DGL	UIL	DIL	Drop
							M3/sec	M3/sec		M3/sec	mm	1 in				m/sec	c	M	M	(M)	(M)	(M)	(M)	(M)
1	MP1	MP2	42373	0	42373	42373	0.076	0.076	2.50	0.190	600	600	0.76	0.72	0.96	0.86	0.19	1485	1485	118.75	120.20	115.75	113.28	
2	MP2	MP4_PS	73039	0	73039	115413	0.131	0.207	2.25	0.466	900	1000	0.81	0.76	0.99	0.89	0.47	965	2450	120.20	119.50	112.98	112.01	0.3

Hydraulic Design for sewer from Lakhanpur to Panki Pumping Station

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recom ended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumul ative length	UGL	DGL	UIL	DIL	Drop
							M3/sec	M3/sec		M3/sec	mm	1 in				m/sec	c	M	M	(M)	(M)	(M)	(M)	(M)
1	MP5	MP6			0	217978	0.000	0.391	2.25	0.880	1200	1500	0.87	0.80	1.01	0.90	0.88	1200	1200	121.49	125.23	118.49	117.69	
2	MP6	MP7	69032	74126	143158	361136	0.257	0.648	2.25	1.458	1600	2000	0.77	0.74	0.97	0.91	1.46	285	1485	125.23	125.30	117.29	117.15	0.4
3	MP7	MP8			0	361136	0.000	0.648	2.25	1.458	1600	2000	0.77	0.74	0.97	0.91	1.46	100	1585	125.30	125.28	117.05	117.00	0.1
4	MP8	MP9			0	361136	0.000	0.648	2.25	1.458	1600	2000	0.77	0.74	0.97	0.91	1.46	1085	2670	125.28	125.21	116.90	116.36	0.1
5	MP9	MP10	104095		104095	465231	0.187	0.835	2.25	1.878	1800	2500	0.81	0.76	0.99	0.89	1.88	130	2800	125.21	124.84	116.16	116.10	0.2
6	MP10	MP11			0	465231	0.000	0.835	2.25	1.878	1800	2500	0.81	0.76	0.99	0.89	1.88	600	3400	124.84	124.70	116.00	115.76	0.1
7	MP11	MP12			0	465231	0.000	0.835	2.25	1.878	1800	2500	0.81	0.76	0.99	0.89	1.88	740	4140	124.70	124.35	115.66	115.37	0.1
8	MP12	MP13_PS	86539		86539	551770	0.155	0.990	2.25	2.227	2000	3000	0.80	0.75	0.98	0.87	2.23	790	4930	124.35	123.21	115.17	114.90	0.2

Hydraulic Design for sewer from Panki to Panka Pumping Station

Sr No	From	To	Popln_ Line	Popln_ Branch	Nodal Popln	Cumulative Population	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Dia Recom ended	Slope	Qa/Qf	d/D	v/V	V actual	Q actual	Length	Cumul ative length	UGL	DGL	UIL	DIL	Drop
							M3/sec	M3/sec		M3/sec	mm	1 in				m/sec	c	M	M	(M)	(M)	(M)	(M)	(M)
1	MP14	MP15			0	714189	0.000	1.281	2.25	1.441	1800	2500	0.63	0.64	0.92	0.83	1.44	360	360	124.07	125.07	119.07	118.93	
2	MP15	MP16	55197		55197	769386	0.099	1.380	2.25	1.553	1800	2500	0.67	0.67	0.93	0.84	1.55	600	960	125.07	124.90	118.83	118.59	0.1
3	MP16	MP17			0	769386	0.000	1.380	2.25	1.553	1800	2500	0.67	0.67	0.93	0.84	1.55	600	1560	124.90	122.88	118.49	118.25	0.1
4	MP17	MP18	45687	120024	165711	935097	0.297	1.678	2.00	1.678	1800	2500	0.73	0.71	0.96	0.87	1.68	600	2160	122.88	122.32	118.15	117.91	0.1
5	MP18	MP19			0	935097	0.000	1.678	2.00	1.678	1800	2500	0.73	0.71	0.96	0.87	1.68	570	2730	122.32	124.85	117.81	117.58	0.1
6	MP19	MP20	29198	19879	49077	984174	0.088	1.766	2.00	1.766	1800	2500	0.77	0.73	0.97	0.88	1.77	90	2820	124.85	123.72	117.48	117.44	0.1
7	MP20	MP21			0	984174	0.000	1.766	2.00	1.766	1800	2500	0.77	0.73	0.97	0.88	1.77	510	3330	123.72	122.00	117.34	117.14	0.1
8	MP21	MP22_PS	93647	121494	215141	1199315	0.386	2.152	2.00	2.152	2000	3000	0.77	0.73	0.97	0.86	2.15	140	3470	122.00	121.74	116.94	116.89	0.2

Cost Estimates

Budgetary cost estimation of the sewers was carried out based on schedule of rates and prevailing market rates and is tabulated below.

From Makrikhera nala to Lakhanpur Pumping station (Cost estimate for trunk sewer).

Table 4.30 Cost Estimation for Trunk Sewer from Makrikhera Nala to Lakhanpur PS

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
1	Excavation				
(a)	Excavation for depth up to 1.5 m below G.L for laying Sewer manholes soil (earth, sand loam and clay) including cutting of joints pits ramming dressing) levelling, refilling of trenches in 20 cm layer watering and ramming the same including removal of surplus earth or other dismantled material upto a distance of 50 m. from the centre of trenches.				
	(a) 0 to 1.5 m depth	Cum	61	8,305	506,605
	(b) 1.5 to 3 m depth	Cum	75	7,423	556,725
	(c) 3 to 4.5 m depth	Cum	93	6,541	608,313
	(d) 4 .5to 6 m depth	Cum	107	5,659	605,513
	(e) 6.0 to 7.5 m depth	Cum	140	4,777	668,780
	(f) 7.5m to 9.0 m depth	Cum	184	1,940	356,960
(b)	Same as item 1(a) but excavation in soil mixed with kankar and boulders				
	(a) 0 to 1.5 m depth	Cum	294	2,077	610,638
	(b) 1.5 to 3 m depth	Cum	338	1,856	627,328
	(c) 3 to 4.5 m depth	Cum	393	1,636	642,948
	(d) 4 .5to 6 m depth	Cum	452	1,415	639,580
	(e) 6.0 to 7.5 m depth	Cum	541	1,195	646,495
	(f) 7.5m to 9.0 m depth	Cum	663	485	321,555
2	Shuttering				
(a)	Provide and fix close timbering in trenches for the depth up to 3 m o 3m below G.L consisting of 40 mm thick approved country wood plank for polling board 125 x 75 mm Indian Sal wood walers and 100 mm dia sal wood ballies for shutting at 1.50m C/C including removal after laying of sewers (both sides of trenches) will be taken as one side for the purpose of payment and measurement i.e. area equals to Length x depth of trenches, Dismantled, timbering material will be the property of the Contractor. Details of cost for 30 m and 3 m deep trench i.e. 90 Sq M area of timbering				
	(a) 0 to 3 m	Sqm	176	3,675	646,800
	(b) 3 to 6 m	Sqm	224	3,675	823,200
(b)	Same as item no.2 (a) but timbering left in trenches *(unused timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	1,392	1,561	2,172,912
(c)	Same as item no.2 (a) but timbering left in trenches *(used timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	584	1,041	607,944
3	Supply of following sizes of RCC spigotted and socketed non pressure pipes				
	(a) 600 mm dia in 1.25 m length	m	1,512.64	1,485	2,246,274
	(b) 900 mm dia in 1.25 m length	m	2,784.76	965	2,687,296
4	Laying jointing of RCC hume pipe				
	Carting following sizes of R.C.C Hume pipe (NP3 Class Socket /spigoted rubber ring jointed and specials from store to the work lowering the same in to the trenches in depth upto 1.5m below G.L true to				

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
	alignment including excavation of earth below G.L invert level of pipe, cost of all jointing material, testing etc, complete but excluding excavation and refilling of trenches from ground level to the invert level of pipe.				
	Rate per meter at different depth				
	600 mm dia pipe				
	(a) 4.5 - 6.0 m	m	558	297	165,726
	(b) 6.0 - 7.5 m	m	608	594	361,152
	(c) 7.5 - 9.0 m	m	676	594	401,544
	900 mm dia pipe				
	(a) 6.0 - 7.5 m	m	1,021	965	985,265
5	RCC	Cum	3,988.58	624	2,488,874
6	Constructing vent shafts	Nos.	16,000	5	80,000
7	Construction of scrapper manhole 2.43 mx1.53 m				
	(a) up to depth 4.57m	Nos.	80,318	17	1,365,406
	(b) upto depth 9.14m	Nos.	14,189	44	624,316
8	Construction of manhole dia 1.52m				
	(a) upto depth 2.28m (type B1)	Nos.	19,352	66	1,277,232
	(b) upto depth 5.03m (type B2)	Nos.	6,088	182	1,108,016
	(c) upto depth 9.14m (type B3)	Nos.	6,747	140	944,580
9	Road restoration				
	Dismantling of tar road for laying sewer including shorting out and stacking serviceable materials and disposal of unserviceable materials upto distance of 60 m and its rein statement after filling and proper compaction of trenches.	Sqm	1,250	7,350	9,187,500
10	Shifting of electric and telephone cables				
	Provision for shifting and reinstatement of electric and telephone cable etc. during excavation and laying of sewer lines	LS			75,000
11	Shifting of temporary water supply lines				
	Provision for temporary shifting of existing sewers and water supply falling in the alignment of conveying main during excavation and the restoring utilities/ services to its original condition	LS			75,000
	Total cost				35,115,477 **(35,115,000)**

Table 4.31 From Lakhanpur Pumping Station to Panki Pumping Station (Cost Estimate for Trunk Sewer)

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
1	Excavation				
(a)	Excavation for depth up to 1.5 m below G.L for laying Sewer manholes soil (earth, sand loam and clay) including cutting of joints pits ramming dressing) levelling, refilling of trenches in 20 cm layer watering and ramming the same including removal of surplus earth or other dismantled material upto a distance of 50 m. from the centre of trenches.				
	(a) 0 to 1.5 m depth	Cum	61	23,858	1,455,338
	(b) 1.5 to 3 m depth	Cum	75	22,083	1,656,225
	(c) 3 to 4.5 m depth	Cum	93	20,308	1,888,644
	(d) 4 .5to 6 m depth	Cum	107	18,533	1,983,031
	(e) 6.0 to 7.5 m depth	Cum	140	16,758	2,346,120
	(f) 7.5m to 9.0 m depth	Cum	184	13,246	2,437,264
	(g) 9.0m to 10.5 m depth	Cum	240	4,175	1,002,000
(b)	Same as item 1(a) but excavation in soil mixed with kankar and boulders				
	(a) 0 to 1.5 m depth	Cum	294	5,965	1,753,710
	(b) 1.5 to 3 m depth	Cum	338	5,521	1,866,098
	(c) 3 to 4.5 m depth	Cum	393	5,077	1,995,261
	(d) 4 .5to 6 m depth	Cum	452	4,634	2,094,568
	(e) 6.0 to 7.5 m depth	Cum	541	4,190	2,266,790
	(f) 7.5m to 9.0 m depth	Cum	663	3,312	2,195,856

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
2	Shuttering				
(a)	Provide and fix close timbering in trenches for the depth up to 3 m o 3m below G.L consisting of 40 mm thick approved country wood plank for polling board 125 x 75 mm Indian Sal wood walers and 100 mm dia sal wood ballies for shutting at 1.50m C/C including removal after laying of sewers (both sides of trenches) will be taken as one side for the purpose of payment and measurement i.e. area equals to Length x depth of trenches, Dismantled, timbering material will be the property of the Contractor. Details of cost for 30 m and 3 m deep trench i.e. 90 Sq M (M2) area of timbering				
	(a) 0 to 3 m	Sqm	176	7,395	1,301,520
	(b) 3 to 6 m	Sqm	224	7,395	1,656,480
(b)	Same as item no.2 (a) but timbering left in trenches *(unused timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	1,392	4,072	5,668,224
	(b) 9 to 12 m	Sqm	1,600	565	904,000
(c)	Same as item no.2 (a) but timbering left in trenches *(used timbering) 0 to 3 m*				
	(a) 6 to 9 m	Sqm	584	2,715	1,585,560
	(a) 9 to 12 m	Sqm	670	377	252,590
3	Supply of following sizes of RCC spigotted and socketed non pressure pipes				
	(a) 1200 mm dia in 1.25 m length	m	4,507.84	1,200	5,409,407
	(b) 1600 mm dia in 1.25 m length	m	7,651.57	1,470	11,247,803
	(c) 1800 mm dia in 1.25 m length	m	10,034.84	1,470	14,751,215
	(d) 2000 mm dia in 1.25 m length	m	12,889.40	790	10,182,626
4	Laying jointing of RCC hume pipe				
	Carting following sizes of R.C.C Hume pipe (NP3 Class Socket /spigoted rubber ring jointed and specials from store to the work lowering the same in to the trenches in depth upto 1.5m below G.L true to alignment including excavation of earth below G.L invert level of pipe, cost of all jointing material, testing etc, complete but excluding excavation and refilling of trenches from ground level to the invert level of pipe. (300 mm dia)				
	Rate per meter at different depth				
	1200 mm dia pipe	Per m			
	(a) 3.0 - 4.50 m	m	1,397	200	279,400
	(b) 4.5 - 6.0 m	m	1,492	100	149,200
	(c) 6.0 - 7.5 m	m	1,625	900	1,462,500
	1600 mm dia pipe				
	(a) 7.5 - 9.0 m	m	2,760	1,470	4,057,200
	1800 mm dia pipe				
	(b) 7.5 - 9.0 m	m	3,296	1,370	4,515,520
	(b) 9.0 - 10.50m	m	3,691	100	369,100
	2000 mm dia pipe				
	(a) 7.5 - 9.0 m	m	3,895	640	2,492,800
	(b) 9.0 - 10.50m	m	4,362	150	654,300
5	PCC (Plain cement concrete)				
	Cement concrete work in bedding below ground level with cement, coarse sand and 20 mm gauge approved stone ballast (1:2:4) including supply of all materials, labour, T & P etc, required for the proper completion of work.				
	(a) 7.5 m to 9.0 m	Cum	3,625.98	1,220	4,423,697
6	RCC (Reinforced cement concrete)	Cum	3,988.58	3,041	12,129,271
7	Constructing vent shafts	Nos.	16,000	10	160,000
8	Construction of scrapper manhole 2.43x1.53				

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
	(a) up to depth 4.57m	Nos.	80,318	35	2,811,130
	(b) upto depth 9.14m	Nos.	14,189	141	2,000,649
	(c) upto depth 14.0 m	Nos.	22,040	1	22,040
9	Construction of manhole dia 1.82m				
	(a) upto depth 2.28m (type C1)	Nos.	26,914	32	861,248
	(b) upto depth 5.03m (type C2)	Nos.	8,715	88	766,920
	(c) upto depth 9.14m (type C3)	Nos.	11,668	81	945,108
10	Construction of manhole dia 2.43x1.53				
	(a) upto depth 4.57m (type D1)	Nos.	68,200	101	6,888,200
	(a) upto depth 9.14m (type D2)	Nos.	15,539	606	9,416,634
	(b) upto depth 14.00 m(type D3)	Nos.	22,136	1	22,136
11	Road restoration				
	Dismantling of tar road for laying sewer including shorting out and stacking serviceable materials and disposal of unserviceable materials upto distance of 60 m and its rein statement after filling and proper compaction of trenches.	Sqm	1,250.	20,753	25,941,250
12	Shifting of electric and telephone cables				
	Provision for shifting and reinstatement of electric and telephone cable etc. during excavation and laying of sewer lines	LS			200,000
13	Shifting of temporary water supply lines				
	Provision for temporary shifting of existing sewers and water supply falling in the alignment of conveying main during excavation and the restoring utilities/ services to its original condition	LS			200,000
14	Provision of trenchless technology (Ref. Table – 4.24)	As per Table 4.26			33,000,000
	Total cost				192,316,896 **(192,317,000)**

Table 4.32 From Panki PS to Panka MPS
(Cost Estimate for Trunk Sewer from Panki PS to Panka STP)

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
1	Excavation				
(a)	Excavation for depth up to 1.5 m below G.L for laying Sewer manholes (earth, sand loam and clay) including cutting of joints pits ramming dressing) levelling, refilling of trenches in 20 cm layer watering and ramming the same including removal of surplus earth or other dismantled material upto a distance of 50 m. from the centre of trenches.				
	(a) 0 to 1.5 m depth	Cum	61	31,038	1,893,318
	(b) 1.5 to 3 m depth	Cum	75	28,471	2,135,325
	(c) 3 to 4.5 m depth	Cum	93	25,676	2,387,868
	(d) 4 .5to 6 m depth	Cum	107	19,914	2,130,798
	(e) 6.0 to 7.5 m depth	Cum	140	8,689	1,216,460
	(f) 7.5m to 9.0 m depth	Cum	184	242	44,528
(b)	Same as item 1(a) but excavation in soil mixed with kankar and boulders				-
	(a) 0 to 1.5 m depth	Cum	294	7,760	2,281,440
	(b) 1.5 to 3 m depth	Cum	338	7,118	2,405,884
	(c) 3 to 4.5 m depth	Cum	393	6,419	2,522,667
	(d) 4 .5to 6 m depth	Cum	452	4,979	2,250,508
	(e) 6.0 to 7.5 m depth	Cum	541	2,173	1,175,593
	(f) 7.5m to 9.0 m depth	Cum	663	61	40,443
2	Shuttering				
(a)	Provide and fix close timbering in trenches for the depth up to 3 m o 3m below G.L consisting of 40 mm thick approved country wood plank for polling board 125 x 75 mm Indian Sal wood walers and 100 mm dia sal wood ballies for shutting at 1.50m C/C including removal after laying of sewers (both sides of trenches) will be taken as one side for the purpose of payment and measurement i.e. area equals to Length x depth of trenches, Dismantled, timbering material will be the property of the Contractor. Details of cost for 30 m and 3 m deep trench i.e. 90 Sq M area of timbering				
	(a) 0 to 3 m	Sqm	176	10,410	1,832,160
	(b) 3 to 6 m	Sqm	224	9,572	2,144,128
(b)	Same as item no.2 (a) but timbering left in trenches *(unused timbering) 0 to 3 m*				-
	(a) 6 to 9 m	Sqm	1392	1,237	1,721,904
(c)	Same as item no.2 (a) but timbering left in trenches *(used timbering) 0 to 3 m*				-
	(a) 6 to 9 m	Sqm	584	825	481,800
3	Supply of following sizes of RCC spigotted and socketed non pressure pipes				-
	(a) 1800 mm dia in 1.25 m length	m	10,034.84	6,660	66,832,034
	(b) 2000 mm dia in 1.25 m length	m	12,889.40	280	3,609,032
4	Laying jointing of RCC hume pipe				-
	Carting following sizes of R.C.C Hume pipe (NP3 Class Socket /spigoted rubber ring jointed and specials from store to the work lowering the same in to the trenches in depth upto 1.5m below G.L true to alignment including excavation of earth below G.L invert level of pipe, cost of all jointing material, testing etc, complete but excluding excavation and refilling of trenches from ground level to the invert level of pipe.				-
	Rate per meter at different Depth				-

Sr.	Items	Units	Rate (Rs.)	Quantity	Amount (Rs.)
	1800 mm dia pipe				-
	(a) 4.5 - 6.0 m	m	2,723	3,336	9,083,928
	(b) 6.0 - 7.5 m	m	2,967	3,324	9,862,308
	2000 mm dia pipe				-
	(a) 4.5 - 6.0 m	m	3,218	280	901,040
5	Sand filling				-
	Sand filling below ground level including supply of all materials labour T & P etc required for proper completion of work				-
	(a) 3.0 m to 4.5 m	Cum	217.056	668	144,993
	(b) 4.50 m to 6.0 m	Cum	231.84	5,860	1,358,582
	(c) 6.0 m to 7.5 m	Cum	252.576	1,987	501,869
6	PCC (Plain cement concrete)				-
	Cement concrete work in bedding below ground level with cement, coarse sand and 20 mm gauge approved stone ballast (1:2:4) including supply of all materials, labour, T & P etc, required for the proper completion of work.				-
	(a) 4.50 m to 6.0 m	Cum	2,995.81	1,445	4,328,942
	(b) 6.0 m to 7.5 m	Cum	3,263.76	2,501	8,162,653
7	Constructing vent shafts	Nos.	16,000	14	224,000
8	Construction of scrapper manhole 2.43x1.53				-
	(a) up to depth 4.57m	Nos.	80,318	48	3,855,264
	(b) upto depth 9.14m	Nos.	14,189	79	1,120,931
9	Construction of manhole dia 2.43 m x1.53 m				-
	(a) upto depth 4.57m (type D1)	Nos.	68,200	184	12,548,800
	(b) upto depth 9.14m (type D2)	Nos.	15,539	295	4,584,005
10	Road restoration				-
	Dismantling of tar road for laying sewer including shorting out and stacking serviceable materials and disposal of unserviceable materials upto distance of 60 m and its rein statement after filling and proper compaction of trenches. Based on the nagar Mahapalika, P.W.D, VNS	Sqm	1,250	13,087	16,358,750
11	Shifting of electric and telephone cables				
	Provision for shifting and reinstatement of electric and telephone cable etc. during excavation and laying of sewer lines	LS			100,000
12	Shifting of temporary water supply lines				
	Provision for temporary shifting of existing sewers and water supply falling in the alignment of conveying main during excavation and the restoring utilities/ services to its original condition	LS			100,000
13	Provision of Trenchless technology (ref. table 4.24)	As per Table 4.26			33,418,000
	Total cost				203,759,955 **(203,760,000)**

Summary of abstract of cost estimates for sewer

Table 4.33 Abstract of Cost Estimates for Sewer Lines

Sewer Districts	Provision	Section	Amount (Rs.)
District I			
1	New sewer	Installation of new domestic sewers in Jajmau tannery industrial area	137,929,000
2	Replacement	Sisamau nala to Parmat pumping station	32,186,000
3	Replacement	Replacement of existing trunk sewer from Rawatpur (I3a) to Hudson school crossing (H) and Relief trunk sewer from Hudson School to Cantonment	575,871,000
District II			
4	Replacement	Duplication and replacement of Existing Sewer from Kidwai Nagar to Munshi Purwa Pumping station	68,613,000
District III			
5	New sewer	Laying of new trunk sewer from Makrikhera nala to Panka Bahadur STP	431,192,000
6		Purchase of sewer cleaning equipments (See Institutional Development Program)	-
		Total Cost	1,245,791,000

4.5 OPERATION & MAINTENANCE ASPECTS

4.5.1 Operational Aspects

(1) General

For a sewer system to perform up to its maximum capacity it is necessary to have a maximum quality operation and maintenance with the help of optimum use of latest techniques, labour, equipment and materials.

The operation maintenance aspects discussed in this section pertain only to the identified priority projects The Kanpur Jal Sansthan is presently operating and maintaining the existing sewerage system of the city and it is pre assumed that KJS will continue to do so in the future as well.

(2) Types of Maintenance

There are two types of maintenance of a sewerage system - preventive and emergency. It is necessary that preventive or routine maintenance are carried out to prevent any breakdown of the system and to avoid emergency operations to deal with clogged sewer lines or over flowing manholes or backing up of sewage into a house or structural failure of the system. Preventive maintenance is more economical and provides for reliability in operations of the sewer facilities. Emergency repairs, which would be very rare if proper maintenance is carried out will also have to be provided for proper inspection and preventive maintenance is a necessity.

(3) Operation and Maintenance of Sewerage System

The organisation responsible for the maintenance of the sewerage system will vary with the size and type of the sewerage system and the relative age of the system. The larger the municipality, the larger and more complexes will be its maintenance organisation. The size of the organisation will vary from a couple of employees to several hundred regular employees. The primary effort of the staff is to maintain sewers free flowing and unobstructed.

The sewer system with its components properly designed and installed is handed over to the person in charge of maintenance who assumes the responsibility to make it function satisfactorily for the benefit of the community. One should have sufficient experience in the design and construction of the system to enable him to perform his task efficiently with an understanding and appreciation of the problems that may arise during maintenance. One has not only to be a technical man but has also to deal with human relations in order to be successful in his work. In service training shall be imparted to the maintenance personnel to improve upon the methods adopted based on the latest trends. Failure to develop a better understanding of human relations and also lack of development of the concept of service to the community generally results in the maintenance part becoming unpopular. The general public is also to be made aware of do's and don'ts to help in keeping the sewers free flowing and unobstructed.

(4) General Practice

General practice used for cleaning of sewers depends upon the diameter of sewer. The methods suggested are as follows.

Small diameters (150 mm to 400 mm): Jetting machines are used to clean these small diameter pipes.
Larger diameters (400 mm - 1100 mm): Bucket cleaning equipment is used.
Larger Diameters (Above 1100 mm): Manual desilting of sewers is practiced.

(5) Manual Cleaning

In manual cleaning method, the silt is collected manually from manholes and large sewers where man-entry is possible. This is however a very slow and risky operation. Proper artificial ventilation and adequate safety precautions are required before the men enter the sewers. The depth of most of the sewers is considerable in some cases; the velocity can also be expected to be low leading to generation of gases. All personnel entering the manhole should have proper safety equipment. There should be forced ventilation by using air blowers on manholes upstream of the concerned length. All such personnel should use safety harness fastened at the other end and another crewmember should monitor crew who has entered the manhole.

(6) Passing Rope Knots and Discs through Sewers

In this method of sewer cleaning, solid split bamboos are passed through sewers from one manhole to the other to create a link. Ropes are attached to this link and a rope link is created between two manholes. A wooden disc with rubber gasket ring or a series of knots of rope are formed and pulled through the sewer to and fro. The inside of the sewer (sewer fabric) gets scrubbed due to this procedure and dislocates the encrusted silt. The freed silt flows away downstream and in this way the sewer can be cleaned from upstream to downstream. This method is labour intensive and hence expensive. Further such vigorous scrubbing sometimes breaks the joints and damages the sewer fabric. This method is therefore no longer adopted in modern sewer maintenance practices.

(7) Utilizing Bucket Cleaning Equipment

In the method of utilizing the bucket cleaning equipment, two winches are installed on two manholes. A rope link is established. A bucket is attached to the rope and pulled from one end to the other. The silt deposited in the sewer is collected in the bucket and is taken out from a manhole. This method can also cause damage to manholes and sewer fabric due to heavy pulling.

(8) Utilizing Jetting and Suction Equipment

Jetting and suction equipment is mounted on a truck chassis. Water is stored in a tank (usually 6000 l capacity) mounted on the truck. This water is jetted in the sewer line using a high-pressure pump and a nozzle system. Fine jets with high velocity are generated. On the forward and the backward pass of the jet, the deposited silt is loosened and gets washed down and is collected in the downstream manhole. From this manhole, it is sucked out in a slurry form to a silt tank mounted on the chassis. Various sizes of jets and suction can be used to clean various diameter sewers. The Indian equipment available is usually effective for sewer up to 300mm diameter and can be used up to 450mm diameter with some modifications. For larger diameter sewers, imported heavy-duty suction and jetting machines can be used. In the latest sewer maintenance programmes, these machines are preferred by all.

4.5.2 Utilities Requirement

(1) Manpower Requirement

Component wise O & M cost is as given below Sewerage Network

Total Length = approx. 70 Kms in phase I

Generally, in most of the developed countries, the sewers are cleaned after every four to five years. However, in most of the Indian cities the municipal solid waste finds its way through the sewerage system. Kanpur, is not an exception and during the site visits it was found that the sewers get chocked with the municipal solid waste, especially plastics. Thus the duration of the sewer cleaning has to be shorter than the standard practices followed in developed nations. Therefore, for this priority projects frequency of sewer cleaning has been proposed as once in two years. Based on this strategy the number of labours required for sewer cleaning is calculated and the same is presented Table 4.34.

Table 4.34 Labour Force Estimated for Sewerage System

Description	Quantity	Unit
Total length of proposed sewer lines in Phase-I	70	Km
No of working days in a year	300	Nos.
Length to be covered in a day	100	m
Length that can be cleaned per day by a team of 10 labours	50	m
No of gangs required	2	Nos.
Per gang members	10	Nos.

Note: Number of working days in a year is assumed as 300.

The Table 4.35 given below calculates the manpower requirement. The figures mentioned below are based on personnel deployment of maintenance crews in other large Indian cities.

Table 4.35 Manpower Cost

Designation	No	Rate/Year (Rs.)	Amount (Rs.)
Executive Engineer exclusive for the maintenance of the sewerage system	0.5	500,000	250,000
Assistant Engineers per sewerage zone	2	300,000	600,000
Junior Engineers (two per sewerage zone)	4	225,000	900,000
Supervisors (one per labour gang as per table above)	2	100,000	200,000
Mechanics (one per administrative zone)	1	125,000	125,000
Labours	20	75,000	1,500,000
Total Manpower Cost			3,575,000

4.5.3 Equipment Cost

A number of equipment would be required for the maintenance of the sewerage system. These would be as per Table 4.36 as listed below.

Table 4.36 Capital Costs of Maintenance Equipment

Sr.	Equipment	Nos.	Unit	Rate /unit (Rs.)	Amount (Rs.)
1	Jetting machines	2	Nos.	4,000,000	8,000,000
2	Suction machine with tankers	2	Nos.	2,500,000	5,000,000
3	Trolley mounted diesel engine and non clog sewage pump sets with all accessories like delivery pipe, suction pipe sluice valve, non return valve etc.	2	Nos.	300,000	600,000
4	Air Blower	2	Nos.	300,000	600,000
5	Maintenance van or equivalent	2	Nos.	750,000	1,550,000
6	Other operation equipment as per manual		Nos.	200,000	200,000
Total (See Institutional Development Programme)					15,900,000

4.5.4 Operation and Maintenance Costs

For the equipment which is specifically bought for the operation and maintenance of the sewerage system, facility for the operation and maintenance would either have to be created in form of garages or existing garages of the UP Jal Nigam / Municipal Corporation would be used. In the present case we recommend that existing facilities be used. Also existing personnel be used for the maintenance of these equipment also.

(1) Maintenance Cost

However the actual costs of Operation and Maintenance of the plants and equipment would have expenditure, which has been provided for here.

Capital cost of equipment	Rs. 15,900,000
Considering life as 15 years	
Rate of maintenance would be about 5%	Rs. 15,900,000 x 5% = Rs. 797,500 Say Rs. 800,000

Table 4.37 Summary Operation and Maintenance Cost

Sr.	Particulars	Amount (Rs./year)
1	Manpower Cost	3,575,000
2	Consumables	300,000
3	Maintenance Cost	800,000
	Total	4,675,000

CHAPTER 5

PRELIMINARY DESIGN OF PUMPING STATIONS

CHAPTER 5 PRELIMINARY DESIGN OF PUMPING STATIONS

Pumping stations is one of the main components of the sewerage system and the preliminary design of the proposed pumping stations is presented in this section of the report.

5.1 PUMPING STATIONS IN SEWERAGE DISTRICT I

A pumping station has been proposed, in the Master Plan, on the right bank of Ganga River at the tail end of Bhagwatdas ghat nala in Sewerage District I.

5.1.1 Review / Collection of Existing Documents

The Master Plan prepared By JICA Study Team was reviewed to access the feasibility of constructing a pumping station for tapping of Bhagwatdas ghat nala near Ordinance factory. This pumping station is provided to pump the sewage from untapped Bhagwatdas ghat nala up to the existing 60” sewer line near Bal Bhawan.

5.1.2 Need for the Scheme for Tapping of Bhagwatdas Ghat Nala Pumping Station

At present, Bhagwatdas ghat nala carries around 8 mld of sewage, which enters into the river Ganga. As this site is located in the slope that falls towards the river Ganga, there is a need to lift and pump the sewage flowing in this nala, thus a pumping station has to be constructed to prevent the sewage flowing into river Ganga.

5.1.3 Master Plan Provisions

As per the Master Plan based on population contributing to this nala the flows are as follows

- 2015 Average 8.10 mld
- 2030 Average 8.00 mld

5.1.4 Survey Works Executed

A reconnaissance survey has been carried by MWH along with the JICA Study Team and UPJN officials.

To facilitate the detailed design, topographical survey in 0.5 hectare, has been carried out. In order to make a contour plan, spot levels at one-meter interval have also been taken.

Soil investigation has been carried out by, exploring boreholes of 20 m depth and collecting disturbed & undisturbed soil samples.

The soil assessment report: -

The top of the soil up to 6 m is filled up in nature underlain by plastic soil .In the full exploration depth of 20 m. Clayey silt of low plasticity (CL group) and silty clay of medium plasticity (CI group) has been found. The N value ranges from 6 to 16 indicating medium to very stiff consistency. Small percentage of Chharri and grit are met at various depths. The water table has been met at 1.75m below ground level.

5.1.5 Scheme for Bhagwatdas Ghat Nala Sewage Pumping Station

Proposed scheme for Bhagwatdas ghat nala includes:

a) Construction of intake weir and training of nala,
b) Diversion of flow to grit chambers,
c) Sewage pumping station screen channel, wet well and valve chamber,
d) Main electrical panel (MEP) and Diesel Genset (DG) room
e) Rising main of 1,210 m length from pumping station to existing 60” sewer line near Bal Bhawan.

5.1.6 Design Engineering Works for Bhagwatdas Ghat Nala Pumping Station

The Bhagwatdas ghat nala pumping station is designed for following design horizon:

a) Civil structures has been designed for year 2030
b) Rising main has been designed for year 2015
c) All mechanical and electrical equipments have been designed for year 2015.

Detailed designs of pumping station was carried out to calculate the most techno- economical design. Based on the selection of pumps, discussed in Section 3, submersible pumps are proposed for this pumping station.

Various components of pumping station include:

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

(1) Design Flow

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

Table 5.1 Design Flow of Bhagwatdas Ghat Nala Pumping Station

	Year 2015			**Year 2030**		
	Population Covered (Nos.)	**Peak factor***	**Average Flow (mld)**	**Population Covered (Nos.)**	**Peak factor***	**Average Flow (mld)**
Bhagwatdas Ghat Nala Pumping station	55,860	2.5	8.1	58,640	2.5	9.09

* As per the CPHEEO Manual

(2) Pumping Station

The unit size of various components of proposed Bhagwatdas ghat nala pumping station is presented in Table 5.2.

Table 5.2 Details of Bhagwatdas Ghat Nala Pumping Station

Sr.	Item	Provision
1.	Pumps for year 2015	3 nos 9.11mld @ 33.17 m head (75 HP, where two nos are working and one is standby) (40HP one nos is. working and one no is stand by) 2 nos 4.05 mld @33.17 m head
	Pumps for year 2030	3 - 10.226 mld at 33.17 m head (2015 pumps to be replaced with these pump (100 HP, two nos are working and one no is. standby) (40HP one no is working and one is stand by) 2 – 4.54 mld at 33.17 m head (2015 pumps to be replaced with these pump
2.	Rising main	1 no – 400 mm dia CI class B x 1,210 m long
3.	Coarse screen channel (40 mm clear spacing)	1 no. – 6.0 m x 1.4 m
4.	Medium screen (20 mm clear spacing)	2 nos. – 6.0 m x 1.4 m
5.	Grit chamber	2 nos 15.25 m x 1.4 m
6.	Wet well	1 nos. – 10.00 m x 3.00 m providing a detention time of 3.75 min.
7.	Valve chamber	1 no. – 10.0 m x 3.5 m

A layout drawing is presented in KAN-PS-BD-1. General arrangement of the pumping station is presented in drawing KAN-PS-BD-2.
The plan and profile of this rising main are presented in drawing KAP-PP-BD-1 & 2.

(3) 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 Table 5.3.

Table 5.3 Details of Allied Buildings

Sr.	Item	Size (m)
1	MEP building	6 x 4
2	DG room & control room	8 x 6
3	4- pole structure	8 x 6
4	Transformer yard	7 x 5

5.1.7 Cost Estimates

Budgetary cost estimation of sewage pumping stations was carried out considering prevailing market rates and applicable schedule of rates. Estimated capital cost and operation & maintenance cost of the pumping station is given below.

(1) Civil Cost

Table 5.4 Capital Cost of Civil Works

Sr.	Item	Cost (Rs.)
1	Inlet, screen channels, dry well and wet well, grit chamber	3,820,000
2	MEP building	144,000
3	DG room / control room	288,000
4	Transformer yard	35,000
5	Staff quarter	1,231,000
	Total	5,518,000

(2) Mechanical Cost

Table 5.5 Capital Cost of Mechanical Works

Sr.	Item	Cost (Rs.)
1	Coarse screen	200,000
2	Screen channel gates	200,000
3	Mechanical screens	850,000
4	Manual screens	60,000
5	EOT for pumps	250,000
6	EOT for screens	200,000
7	Pumps	3,638,000
8	Piping and valves	200,000
9	Conveyor belt	450,000
	Total	6,048,000

(3) Electrical and Instrumentation cost

Table 5.6 Capital Cost of Electrical and Instrumentation Works

Sr.	Item	Cost (Rs.)
1	Provision for grid power supply	6,500,000
2	Power supply equipment & stand by power	9,336,000
3	Cables	1,158,000
4	Earthing and safety equipment	273,000
5	Lighting	141,000
6	Instrumentation	1,023,000
7	Miscellaneous	111,000
	Total	18,542,000

(4) Rising Main

Table 5.7 Capital Cost of Rising Main

Sr.	Item	Cost (Rs.)
1	CI B class pipe	4,767,000
2	Appurtenances	300,000
3	Excavation	183,000
4	Miscellaneous (crossing / encasement)	100,000
	Total	5,350,000

5.1.8 Abstract of Costs for Bhagwatdas Ghat Nala Pumping Station

Table 5.8 Abstract of Cost of Bhagwatdas Ghat Nala Pumping Station

Sr.	Item	Cost (Rs.)
1	Civil cost	5,518,000
2	Mechanical cost	6,048,000
3	Electrical & instrumentation cost	18,542,000
4	Rising main cost	5,350,000
	Total capital cost	35,458,000

5.1.9 Operation & Maintenance Cost of Bhagwatdas Nala Pumping Station

Table 5.9 Operation and Maintenance Cost of Bhagwatdas Ghat Nala Pumping Station

Sr.	Item	Cost (Rs.) per annum
1	Manpower cost	422,000
2	Power cost (20 hrs @ Rs.3.25/kWh)	1,416,000
3	Diesel cost (4 hrs @ Rs. 34/liter)	823,000
4	Maintenance of civil works @ 1.5 %	83,000
5	Maintenance of M&E works @ 3 %	738,000
6	Maintenance of rising main @ 0.25 %	13,000
	Total annual O & M cost	3,495,000

Power cost depends on peak flow

5.2 SEWAGE PUMPING STATIONS FOR SEWERAGE DISTRICT III

The sewage from this district will be collected through the proposed trunk sewer. The sewage will reach Lakhanpur pumping station by gravity. From this PS, the sewage will be carried to the intermediate pumping station at Panki near Panki canal by gravity. Again the sewage will reach to the proposed MPS at Panka (near Pandu river) by pumping and gravity. Finally the sewage will reach Treatment Plant at Panka Bahadur Nagar by pumping it from MPS at Panka.

5.2.1 Review / Collection of Existing Documents

The Master plan prepared by JICA Study Team was reviewed to assess the feasibility of constructing the proposed lift pumping station near Panki canal. The sewage from this lift pumping station will be further pumped through another proposed terminal pumping station proposed at Panka near the proposed STP site.

5.2.2 Need for the Scheme

Sewage pumping stations are proposed near Panki canal and at Panka Bahadur Nagar near STP site to maintain the hydraulics. This pumping station will receive sewage from proposed trunk sewer from Makrikhera nala near Lakhanpur and convey the same to the inlet of STP at the required elevation.

5.2.3 Master Plan Provisions

Master Plan proposes to construct two new pumping stations one near Panki and another at Panka near STP site.

5.2.4 Survey Works Executed

A reconnaissance survey has been carried out by MWH along with the JICA Study Team and UPJN officials.

To facilitate the detailed design, topographical survey, has been carried out. In order to make a contour plan, spot levels at one-meter interval have also been taken. Soil investigation has been carried by exploring 20 m boreholes and collecting disturbed and undisturbed soil samples.

Soil assessment report (sample taken inside the premises of proposed Panki PS): -

The soil strata are predominantly plastic in nature, in the full exploration depth of 20m, consisting of sandy silt of very low plasticity (ML group), Clayey silt of low plasticity (CI group) and silty clay of medium plasticity (CI group). The N values range from 5 to 20 indicating medium to very stiff consistency. Small percentage of pebbles and grit are met at various depths. Non plastic soil is present from 0.50 to 1.40m, 4 to 4.60m and 10 to 15 m. The corrected N values in non plastic soil strata range from 15 to 19 indicating medium relative density. The water table has been met at 2.90 m below GL. The net safe bearing capacities on shear considerations and allowable bearing pressure on settlement considerations are computed for 6 and 12 m depths.

The soil strata in the full exploration depth of 20 m are alternatively plastic and non plastic in nature consisting of clayey silt of low and silty soil of very low plasticity (CL and ML group), Silty clay of medium plasticity (CI group), silty sand (SM group) and poorly graded fine sand (SM- SP group) .The N value in plastic strata ranges from 4 to 13 indicating medium to stiff consistency. Small percentage of Pebbles and Grits is met at all depth. The corrected values in non – plastic strata ranges from 14 to 20 indicating medium relative density. The water has been met at 0.40m below GL. A net safe bearing capacities on shear considerations and allowable pressures on settlement considerations are computed for 6 and 12 m depths.

Soil assessment report (Panka main pumping station): -

The soil strata are predominantly plastic in nature, in the full exploration depth of 20m, consisting of sandy silt of very low plasticity (ML group), Clayey silt of low plasticity (CI group) and silty clay of medium plasticity (CI group). The N values range from 5 to 20 indicating medium to very stiff consistency. Small percentage of pebbles and grit are met at various depths. Non plastic soil is present from 0.50 to 1.40m, 4 to 4.60m and 10 to 15 m. The corrected N values in non plastic soil strata range from 15 to 19 indicating medium relative density. The water table has been met at 2.90 m below GL. The net safe bearing capacities on shear considerations and allowable bearing pressure on settlement considerations are computed for 6 and 12 m depths.

5.2.5 Design Engineering Works

Three pumping stations are designed for the following horizon:

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

Detailed designs of pumping stations were carried out to calculate the most techno- economical design in combination to various options of pumping. Based on the discussions in Section 3, horizontal type centrifugal pumps have been provided in these pumping stations as the required capacity of individual pumps works out to more than 270 HP.

Various components of the above two pumping stations 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
g) Civil structure shall be designed for year 2030
h) Rising main shall be designed for year 2015
i) All mechanical and electrical equipment shall be designed for year 2015
j) Provision of extra space for pumps after year 2015 shall be made in the civil structure

5.2.6 Design Flow

The projected sewage flow to be received at the pumping stations, as discussed in Section 4, are presented in the following table.

Table 5.10 Design Flow of Sewage Pumping Stations

Sr.	Pumping Station	Sewage Flow (mld)	
		2015	2030
1	Panka main pumping station	120	200
	Peak factor as per the CPHEEO manual	2.25	2.25
2	Panki pumping station	80	126
	Peak factor as per the CPHEEO manual	2	2

5.2.7 Panka Main Pumping Station

Two possible locations are examined for the location of proposed pumping station at Panka

(1) across the Pandu river, near site of the proposed STP and
(2) on the cis side of Pandu river.

In the first case the river will have to be crossed by a deep sewer but because crossing of river would be difficult and not cost effective, as well as because procurement of land across the river was not possible, across the river proper alignment for a sewer line is not available, the alternative (2) has been selected for siting of the Panka MPS. The proposed site is in the wedge between the bypass road and the river Pandu near Bhauti, the rising main is proposed to cross the river from below the bed of the river with provision for encasing.

(1) Unit Sizes for MPS at Panka

Horizontal type centrifugal pumps have been provided at this MPS. Accordingly, a dry well and a wet well are provided.

Table 5.11 Details of Panka Pumping Station

Sr.	Item	Provision
1	Pumps for year 2015	9 nos, 40 mld, @22.07 m head (270 HP, where six nos are working, and three nos are standby)
	Pumps for year 2030	6 nos (additional), 40 mld, @22.07 m head (270 HP where ten nos are working, and five nos are stand by)
2	Rising main	1 no. 1400 mm dia pre stressed concrete pipe, 1,500 m length (m)
3	Coarse screen channel (40 mm clear spacing)	2 nos 6.0 m x 6.40 m
4	Medium screen channel (20 m clear spacing)	8 nos 6. 0m x1.60m
5	Wet well	1 nos 46m x 15 m detention time 5 min.
6	Dry well	1 nos 52m x 10m

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

The plan and profile of this rising main are presented in drawing KAP-PP-MP_RM3-1.

(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 5.12 Details of Allied Building

Sr.	Item	Size (meter)
1	MEP building	10 x 8
2	DG room & control room	12 x 8
3	Transformer yard	12 x 10
4	4 -Pole structure	8 x 6

(3) Capital Cost Estimates

Budgetary cost estimation of sewage pumping stations was carried out considering prevailing market rates and applicable schedule of rates. Estimated capital cost and operation & maintenance cost of the pumping station is given below.

Civil Cost

Table 5.13 Capital Cost of Civil Works at Panka MPS

Sr.	Item	Cost (Rs.)
1	Inlet, screen channels, dry well and wet well	52,009,000
2	MEP building	480,000
3	DG room / control room	720,000
4	Transformer yard	120,000
5	4 -Pole structure	48,000
6	Staff quarter	1,231,000
	Total	54,608,000

Mechanical Cost

Table 5.14 Capital Cost of Mechanical Works at Panka MPS

Sr.	Item	Cost (Rs.)
1	Coarse screen	400,000
2	Screen channel gates	1,040,000
3	Mechanical screens	1,700,000
4	Manual screens	120,000
5	EOT for pumps	250,000
6	EOT for screens	200,000
7	Pumps	10,145,000
8	Piping and valves	2,000,000
9	Conveyor belt	450,000
	Total	16,305,000

Electrical and Instrumentation cost

Table 5.15 Capital Cost of Electrical and Instrumentation Works at Panka MPS

Sr.	Item	Cost (Rs.)
1	Provision for grid power supply from the adjacent 33 kV switch yard at point of supply in MPS	22,135,000
2	Panels	30,958,000
3	Cables	5,850,000
4	Earthing and safety equipment	429,000
5	Lighting	195,000
6	Instrumentation	1,082,000
7	Miscellaneous	259,000
	Total	60,908,000

Rising Main

Table 5.16 Capital Cost of Rising Main at Panka MPS

Sr.	Item	Cost (Rs.)
1	PSC pipe	11,745,000
2	Appurtenances	300,000
3	Excavation	626,000
4	Miscellaneous (crossing / encasement)	100,000
	Total	12,771,000

(4) Abstract of Costs estimates for MPS at Panka

Table 5.17 Abstract of Cost Estimates for Panka MPS

Sr.	Item	Cost (Rs.)
1	Civil cost	54,608,000
2	Mechanical cost	16,305,000
3	Electrical & instrumentation cost	60,908,000
4	Rising main cost	12,771,000
	Total capital cost	144,592,000

(5) Operation & Maintenance Cost of MPS at Panka

Table 5.18 Operation and Maintenance Cost Estimates for Panka MPS

Sr.	Item	Cost (Rs.) per annum
1	Manpower cost	198,000
2	Power cost (20 hrs @ Rs.3.25/kWh)	14,336,000
3	Diesel cost (4 hrs @ Rs. 34/liter)	8,332,000
4	Maintenance of civil works @ 1.5 %	819,000
5	Maintenance of M&E works @ 3 %	2,316,000
6	Maintenance of rising main @ 0.25 %	32,000
	Total annual O & M cost	26,033,000

Power cost depends on peak flow

5.2.8 Panki Pumping Station

This pumping station to be located on a site before the crossing of the Lower Ganga canal; coming along the alignment of sewer.

(1) Unit Sizes for Panki Pumping Station

Submersible type centrifugal pumps have been provided at this pumping station. Accordingly, a wet well and valve chamber is provided.

Table 5.19 Details of Panki Pumping Station

Sr.	Item	Provision
1	Pumps for year 2015	6 nos 47.25 @12.94 m head (150 HP, where four nos are working and two nos are stand by)
	Pumps for year 2030	9 nos 47.25 @12.94 m head (150 HP, where six nos working and three nos are stand by)
2	Rising main	1 no. 1200 mm dia pre stressed concrete pipe length 260 m
3	Coarse screen channel 40 mm clear spacing	2 No. 6 m x 4.05 m
4	Medium screen channel 20 mm clear spacing	4 nos 6 m x 4m
5	Wet well	1 no. 28m x 18 m providing five minute detention time
6	Valve chamber	1 nos 28.0m x 6.0 m

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

The plan and profile of this rising main are presented in drawing KAP-PP-MP-RM2-1.

(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 5.20 Details of Allied Buildings

Sr.	Item	Size (meter)
1	MEP building	7 x 5
2	DG room & control room	8 x 6
3	Transformer yard	8 x 6
4	4 pole structure	8 x 6

(3) Capital Cost for Panki Pumping Station

Budgetary cost estimation of sewage pumping stations was carried out considering prevailing market rates and applicable schedule of rates. Estimated capital cost and operation & maintenance cost of the pumping station is given below.

Civil Cost

Table 5.21 Capital Cost Estimates of Civil Works at Panki Pumping Station

Sr.	Item	Cost (Rs.)
1	Inlet, screen channels, dry well and wet well	34,135,000
2	MEP building	210,000
3	DG room / control room	288,000
4	Transformer yard	48,000
5	Staff quarter	1,231,000
6	4 pole structure	48,000
	Total	35,960,000

Mechanical Cost

Table 5.22 Capital Cost Estimates of Mechanical Works at Panki Pumping Station

Sr.	Item	Cost (Rs.)
1	Coarse screen	150,000
2	Screen channel gates	600,000
3	Mechanical screens	1,700,000
4	Manual screens	150,000
5	EOT for pumps	250,000
6	EOT for screens	200,000
7	Pumps	14,191,000
8	Piping and valves	2,000,000
9	Conveyor belt	450,000
	Total	19,691,000

Electrical and Instrumentation cost

Table 5.23 Capital Cost Estimates of Electrical and Instrumentation Works at Panki Pumping Station

Sr.	Item	Cost (Rs.)
1	Provision for grid power supply	7,850,000
2	Panels	15,531,000
3	Cables	2,633,000
4	Earthing and safety equipment	293,000
5	Lighting	182,000
6	Instrumentation	1,023,000
7	Miscellaneous	117,000
	Total	27,629,000

Rising Main

Table 5.24 Capital Cost Estimates of Rising Main at Panki Pumping Station

Sr.	**Item**	**Cost (Rs.)**
1	PSC pipe	1,603,000
2	Appurtenances	300,000
3	Excavation	93,000
4	Miscellaneous (crossing / encasement)	100,000
	Total	2,096,000

(4) Abstract of Costs for Panki Pumping Station

Table 5.25 Abstract of Cost Estimates of Panki Pumping Station

Sr.	**Item**	**Cost (Rs.)**
1	Civil cost	35,960,000
2	Mechanical cost	19,691,000
3	Electrical & instrumentation cost	27,629,000
4	Rising main cost	2,096,000
	Total capital cost	85,376,000

(5) Operation & Maintenance Cost for Panki pumping station

Table 5.26 Operation and Maintenance Cost Estimates of Panki Pumping Station

Sr.	**Item**	**Cost (Rs.) per annum**
1	Manpower cost	911,000
2	Power cost (20 hrs @ Rs.3.25/kWh)	5,310,000
3	Diesel cost (4 hrs @ Rs. 34/liter)	3,086,000
4	Maintenance of civil works @ 1.5 %	539,000
5	Maintenance of M&E works @ 3 %	1,420,000
6	Maintenance of rising main @ 0.25 %	5,000
	Total annual O & M cost	11,180,000

Power cost depends on peak flow

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 Panka Bahadur nagar under the Master Plan, 2004 prepared by JICA Study Team.

6.2 NEED FOR THE SCHEME

The sewerage District III, which is bounded by the Pandu river to the south, development plan boundaries to the west and north and the Kanpur – Jhansi railway line to the east.

This area is devoid of proper sewerage system with only few lines in this district. Lakhanpur area towards north of GT road is provided with sewers. A temporary outfall has been provided in the nala along Kalyanpur road to Naubasta village. Sewage from this area is proposed to be diverted to Panka MPS and to STP.

This STP will treat the sewage to the desired standards and the treated effluent shall be discharged into Pandu river. This treated effluent may also be used for irrigation purposes in the close vicinity to the STP site. This will reduce, to some extent, further exploitation of the ground water in the vicinity.

6.3 MASTER PLAN PROVISIONS

Master Plan has proposed the STP to cater to the sewage generated in District III. The capacity of this plant has been planned for ultimate capacity of 200 mld for year 2030.

Master Plan recommends UASB with post treatment by aerated lagoons as the preferred treatment process based on detailed comparison of various treatment options. The treated effluent can be discharged into the Pandu river or alternatively to irrigation. Chlorination is preferred for disinfections against provision of maturation ponds due to large area requirement.

6.4 SURVEY WORKS EXECUTED

UP Jal Nigam has identified a 90 hectares site for the construction of STP, towards the east of Kanpur city in Panka village. In total, survey of 90 hectares was done by MWH in which 45 hectares has been identified for the construction of STP.

MWH carried out a reconnaissance survey of the identified site with UP Jal Nigam officials and JICA Study Team. It was followed by detailed survey at this site.

Also, revenue (khasara) maps of this village were collected to identify the exact plots. The plot boundary of the proposed STP site was marked by MWH team on the revenue map

Topographical Survey

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

Geo Technical Survey

Five bore holes, each of 20 m depth, were bored to assess the soil profile at the proposed site. The results were used while finalizing the design of STP units.

Soil Assessment Report

The soil strata is predominantly plastic soil, in the full exploration depth of 20 m, consisting of sandy silt of very low plasticity (ML group), clayey silt of low plasticity (CL group), and silty clay of medium plasticity (CI group). The N-values range from 5 to 20 indicating medium to very stiff consistency. Small percentage of pebbles and grit are met at various depths. Non sand silt (ML group), silty sand (SM group) are inter spread in the plastic soil from 5.50 to 7.0m and 10.0 to 16.50 m.. The corrected N values in non- plastic soil strata range from 7 to 18 indicating soft to medium relative density. The water table has been met at 6.10m below GL.

The net safe bearing capacities on shear considerations and allowable bearing pressures on settlement considerations are computed for 6 and 12m depth.

6.5 DESIGN ENGINEERING WORKS

6.5.1 Design Flow

Table 6.1 Design Flow at Panka STP

Sr.	Parameter	2015	2030
1	Average flow (mld)	120	200
2	Average flow (m^3/hr)	5,000	8,333
3	Peak flow (m^3/hr)	10,000	16,667

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 65 to 140 mg/l.

The catchment area of Panka STP is fast developing and the basic amenities like sewers are being provided in all the new developing areas 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 Panka are presented in the Table 6.2.

The following wastewater characteristics are used for design of sewage treatment plant.

Table 6.2 Raw Sewage Characteristics Considered for Design Purpose

Sr.	Parameter	Average Value
1	Minimum temperature, ^oC	20
2	pH	6.0 - 8.5
3	Biochemical oxygen demand (BOD_5), mg/l	230
4	Total suspended solids, mg/l	500
5	Faecal coliform count, MPN/100ml	1×10^6

6.5.3 Discharge Standards

NRCD have conveyed the recommendations of the Expert Committee through their letter no DO. 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 is therefore designed so as to achieve treated wastewater of equal or better quality as mention in the Table 6.3 hereunder.

Table 6.3 Treated Wastewater Quality

Sr.	Parameter	Value (Irrigation Field / River)
1	pH	5.5 – 9.0
2	Biochemical oxygen demand (BOD_5), mg/l	$\leq$ 30
3	Total suspended solids, mg/l	$\leq$ 50
4	Faecal coliform count, MPN/100ml	Desired $\leq$1,000 Permissible $\leq$10,000

Treatment Scheme

The capacity of STP at Panka is 120 mld in phase - I. As discussed in the earlier section, a pumping station is proposed on the north side of Pandu river, which will deliver sewage to the required elevation through a rising main. Horizontal type centrifugal pumps are provided 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. KAN-STP-PANKA-3.

STP at Panka 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

The rising main from MPS 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 Pandu river or alternatively taken for irrigation.

The sludge form UASB reactor is taken to sludge drying beds for dewatering before its disposal. 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.

6.5.4 Unit Description

(1) Inlet Chamber

An inlet chamber is provided ahead of screen channel to receive the sewage from the MPS 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. The bars arrest the floating materials, which have to be removed periodically.

Mechanical screens are provided with four units working and two manual screen units as standby unit. The screening process is undertaken by screen consisting of 50 mm x 10 mm thick flats with 12 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, has been provided keeping in view the maintenance of mechanical detritor.

(4) Upflow Anaerobic Sludge Blanket (UASB) Reactor

After screening and degritting, 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 from 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. Organic compounds there after 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 of one 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 half a day is provided for settlement of suspended solids.

(6) Chlorination System

A chlorination system has been provided to meet the faecal coliform standards in case the treated water from the AL does not meet the faecal discharge 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 will take place in the chlorine contact tank by way of adequate contact time with chlorine. Baffle walls are provided to ensure proper contact.

6.5.5 Sludge Dewatering System

Sludge Dewatering System will consist of the following:

- Sludge Pumping Station
- Sludge Drying Beds

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

A 250 micron size 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. Pumps of adequate capacity are provided for conveyance of filtrate back to the inlet chamber.

(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 will be 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

(3) Gas Utilisation System

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.

6.5.6 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 will be 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 the above two available options, use of sludge as manure is found most techno-economical alternative.

6.5.7 Biogas Utilisation

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 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 Panka have been 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 6.4 Design Parameters for Panka STP

Sr.	Parameter	Value	Unit
Average flow		1.389	cum/sec
Peak factor		2.0	
Peak flow		2.778	cum/sec
Sewage Treatment Plant:			
1.	Inlet Chamber		
	Hydraulic retention time (Min)	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 20o 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.	Facultative Type of 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 UNITS SIZES

6.7.1 Civil Works

The treatment scheme adopted for STP at Panka consists of the following units. A detailed process design has been carried out and the required sizes are also presented in the following table.

Table 6.5 List of Plant Units

Sr.	Units	No.	Size (meter)
1	Inlet chamber	1	2.0 x 8.6 x 5.0 LD + 0.5 FB
2	Screen channel	4+2	5.0 x 2.0 x 1.0 LD + 0.5 FB
3	Detritor tank	3	10.4 x 10.4 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	24	2.3 x 2.25
7	UASB Reactor	12	32.0 x 26.0 x 5.7 LD + 0.5 FB
8	Aerated lagoon Aeration zone Quiescent zone	 2 2	 70.8 x 141.3 x 3.0 LD + 0.5 FB 283.1 x 141.3 x 1.5 LD + 0.3 sludge depth + 0.5 FB
9	Chlorine mixing tank	1	8.2 x 8.2 x 2.5 LD + 0.5 FB
10	Chlorine contact tank	1	44.7 x 22.4 x 2.5 LD + 0.5 FB
11	Sludge drying beds	50	28.7 x 16.9
12	Sludge pumping station	2	2.5 x 4.0
13	Filtrate pumping station	1	2.5 x 4.0
14	Gas holder	1	10.2 dia x 4.5 TD
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

A general layout showing the proposed STP at Panka based on the UASB process followed by aerated lagoon with chlorination system is presented in drawing no. KAN-STP-PANKA-1. The hydraulic flow diagram for this treatment plant is presented in drawing no. KAN-STP-PANKA-2.

6.7.2 Mechanical Works

Panka STP consists of the following mechanical equipment.

Table 6.6 List of Mechanical Works

Sr.	Units	No.	Rating (HP)
1	Mechanical screen	4	5.0
2	Conveyor belt	1	5.0
3	Detritor mechanism	3	5.0
4	Aerators	8	50.0
5	Sludge pumps	2	20.0
6	Filtrate pumps	4	15.0
7	Gas holder accessories	1	-
8	Gas flaring system	1	-
9	Chlorinators	1	5.0
10	Gates	8	-
11	EOT and chain pulley	3	5.0
12	Generator	1	-

6.7.3 Electrical & Instrumentation Works

Following components have been considered for electrical and instrumentation works for Panka STP.

Table 6.7 List of Electrical & Instrumentation Works

Sr.	Units	No.
1	4 pole structures	1
2	33kV overhead transmission line	2.5 km
3	48V DC sealed maintenance free battery & battery charger	1
4	33kV Vacuum circuit breaker panel	1
5	Gas engine synchronization and AMF panel	1
6	33/0.433kV Dyn11, ONAN cooled transformer with off circuit tap changer	2
7	Main electrical panel	1
8	Screen & grit removal mechanism panel	1
9	Aerator & chlorine house panel	1
10	Sludge pump panel	1
11	Filtrate pump panel	2
12	Main lighting panel	1
13	Sub lighting panels	6
14	125 kVAr capacitor control panel with APFC relay	1
15	33kV & 1.1kV cables, cable terminations & cable carrier system	Lot
16	Indoor & outdoor lighting	Lot
17	Earthing & safety equipment	Lot
18	Instrumentation system	Lot

6.8 CAPITAL COST

6.8.1 Civil Cost

Table 6.8 Capital Cost of Civil Works

Sr.	Units	Civil Cost (Rs.)
1	Inlet chamber	710,000
2	Screen channel	450,000
3	Grit chamber	2,109,000
4	Division box – 1	656,000
5	Division box – 2	1,230,000
6	Distribution box	11,640,000
7	UASB Reactor	164,037,000
8	Aerated lagoon Aeration zone Quiescent zone	 9,004,000 20,001,000
9	Chlorine mixing tank	656,000
10	Chlorine contact tank	6,300,000
11	Sludge drying beds	24,252,000
12	Sludge pumping station	171,000
13	Filtrate pumping station	95,000
14	Gas holder	1,544,000
15	MEP room	660,000
16	Generator room	400,000
17	Transformer yard	180,000
18	Interconnecting piping, roads and pathways	6,196,000
19	Interconnecting channels	4,800,000
20	Treated effluent channel	2,250,000
21	Chlorine room	360,000
	Total	247,701,000

6.8.2 Mechanical Cost

Table 6.9 Cost of Mechanical Works

Sr.	Units	Mechanical Cost (Rs.)
1	Mechanical screen	5,672,000
2	Conveyor belt	400,000
3	Detritor mechanism	4,500,000
4	Aerators	2,800,000
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	22,000,000
	Total	40,292,000

6.8.3 Electrical & Instrumentation Cost

Table 6.10 Cost of Electrical & Instrumentation Works

Sr.	Units	Electrical & Instrumentation Cost (Rs.)
1	Provision for receiving power at point of supply	8,500,000
2	Panels	6,606,000
3	Cables	4,293,000
4	Lighting	937,000
5	Earthing and safety equipment	608,000
6	Instrumentation	765,000
7	Miscellaneous	219,000
	Total	21,928,000

Utilities

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

Table 6.11 Cost of Utility Items

Sr.	Units	Utility Cost (Rs.)
1	Administrative building cum laboratory	1,080,000
2	Furniture	500,000
3	Laboratory equipment	1,200,000
4	Tube well and water supply system	680,000
5	Site drainage	350,000
6	Security room	50,000
7	Staff quarter	4,363,000
8	Green belt	150,000
9	Wheel barrow and trolley mounted pump	300,000
10	Fire fighting arrangement	80,000
11	Site development	300,000
12	Bypass arrangement	8,000,000
13	Outfall structure	300,000
14	Boundary wall	7,400,000
15	Vehicle	600,000
16	Site development	1,200,000
17	Miscellaneous	500,000
18	Irrigation Channel	43,750,000
	Total	70,803,000

6.8.4 Land Cost

A total of 45 hectares of land is required for construction of STP at Panka. This land provision includes the requirement for both phases i.e. 120 mld in year 2015 and 200 mld in year 2030.

Table 6.12 Land Cost

Sr.	Particulars	Costs (Rs.)
1	Land cost for 45 ha @ Rs. 1,461,000	65,745,000
	Total	65,745,000

6.9 OPERATION & MAINTENANCE

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 treatment plant is very much required for sustainability of the treatment plant 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 treatment plant are scheduled and co-ordinated by the plant manager. The plant manager will also be responsible for taking steps like shutting down the plant or to bypass the wastewater in case of emergencies, after having proper deliberations with the management and the operational staff.

6.9.2 Screens

Screens are provided to remove the large floating material in the raw wastewater. Each of the working screen channels will have one mechanically cleaned bars screen with bar clearance of 6 mm opening at STP site and one manually cleaned mesh screen with opening of 25 mm x 25 mm, located on the downstream of fine screen.

The standby screen channel will have one manually cleaned bars screen with bar clearance of 12 mm opening at STP and one manually cleaned mesh screen with opening of 25 mm x 25 mm, located downstream of the manually cleaned 12 mm opening bars screen.

Table 6.13 Operation and Maintenance Aspects of Screens

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

Table 6.14 Operation and Maintenance Aspects of Mechanical Grit Removal

Operational	Maintenance
• The time & 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, samples from the reactor should be taken periodically 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 6.15 Operation and Maintenance Aspects of UASB

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 wheelbarrows.	• Levelling and alignment of the weirs and the gutters should be checked properly twice in a year. • The notches should be cleaned frequently

6.9.5 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 6.16 Operation and Maintenance Aspects of Sludge 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	• Drainpipes 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

6.9.6 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 should be periodically checked against leakage. If any leakage is found, should be repaired by isolating the line with the help of valves. Gas dome of gasholder should be epoxy painted, break glass seal & emergency alarm for vacuum/ excess gas condition should be checked for functioning. Gas flaring system should be operated & maintained as per manufacturer guideline.

6.9.7 Chlorination System

Chlorination equipment should be properly housed and reserve supply of cylinders, valves, gaskets etc. should always be available. Valves and piping should be regularly checked for leaks. Leaks should be attended to as per the instruction in the manufacturer's catalogues. Chlorine cylinders should 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 should 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.

6.9.8 Sludge Pumps

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

6.9.9 Manpower Requirement

The manpower requirement for operation and maintenance for Panka STP is presented in the Table 6.7. The plant manager, a person at a level of Executive Engineer, will head the team. The Plant Manager will be assisted by Assistant Engineers, Junior Engineers and other supporting staff.

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

- The management level
- The operational level
- Supporting staff of the treatment plant

The plant manager, plant engineer and process engineer come under the management level, who 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 6.17 Proposed Staffing for Sewage Treatment Plant

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	UDC Senior Assistant	_	6 days/week	2
15	LDC Junior Assistant	_	6 days/week	3
16	Peon	_	6 days/week	3
17	Jr. Steno	_	6 days/week	1
18	Chemist	MSc (Chemistry	6 days/week	1
19	Assistant Chemist	BSc (Chemistry)	6 days/week	1
20	Lab Assistant	_	6 days/week	1
21	Lab Attendant	_	6 days/week	2
22	Sweeper	_	6 days/week	2
23	Welder	ITI	6 days/week	1
24	Operator	ITI	6 days/week	19
25	Labourer	-	6 days/week	73

6.9.10 Operation and Maintenance Cost Estimates

(1) Operation Cost

Table 6.18 Operation Cost

Sr.	Particulars	Costs per annum (Rs.)
1	Power	9,251,000
2	Manpower	7,458,000
3	Chemical	1,488,000
	Total	18,197,000

(2) Maintenance Cost

Table 6.19 Maintenance Cost

Sr.	Particulars	Costs per annum (Rs.)
1	Civil @1.5% per year	3,716,000
2	Mechanical, electrical and instrumentation @ 3% per year	1,867,000
	Total	5,583,000

(3) Total Operation & Maintenance Cost 1

Table 6.20 Total O&M Cost

Sr.	Particulars	Costs per annum (Rs.)
1	Operation & Maintenance Cost	23,780,000

CHAPTER 7

INSPECTION, CLEANING AND REHABILITATION OF SEWER

CHAPTER 7 INSPECTION, CLEANING AND REHABILITATION OF SEWER

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 Kanpur city was commissioned in 1910’s. Considering the importance of existing sewer as a part of overall sewerage system of Kanpur, JICA Study Team considered the inspection, cleaning and rehabilitation of sewer stretches presented in Table 7.1, under priority projects.

Table 7.1 Sewer Stretches Proposed for Rehabilitation

Sr.	Sewerage District
A. Sewerage District I	
1	Company BaGH to Parmat SPS
2	DAV Hostel to Parmat SPS
3	VIP Road to Nawab ganj
4	DIG Bungalow to Parmat
5	Mac Roberts ganj to Sisamau
6	Kamala tower to Phool bagh
7	Phool bagh to Chhabile Purwa meeting point of 84" sewer
8	Pan chakki to meeting point of 78" sewer
9	GT Road to Cantonment
10	Tube well no.5 Cantt to Chhabile Purwa
11	Chhabile Purwa to Jajmau CSPS (Jajmau A line)
B. Sewerage District II	
1	Israuddin clinic to Harihar Nath
2	Chinyot Bhavan Govind Nagar to Harihar Nath Shastri Park
3	Geeta nagar Crossing to ITI Chauraha

Preliminary investigation on trunk sewers was carried out through manhole survey, under Feasibility Study to propose a structured inspection, cleaning and rehabilitation plan. Based on the preliminary investigation it is concluded that there is problem of silting, which can be rectified through proper maintenance in the following stretches.

- Company bagh to Parmat SPS
- DAV hostel to Parmat SPS
- VIP road to Nawab ganj
- DIG Bungalow to Parmat
- Mac Roberts ganj to Sisamau
- Kamala tower to Phool bagh
- Chinyot Bhavan Govind Nagar to Harihar Nath Shastri Park

7.1 BASICS OF SEWER REHABILITATION PLAN

Indian cities show a certain trend of development characterized by rapid unplanned growth of cities, its population and 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. In such cases Trenchless Technology is probably the only solution to keep the underground assets in satisfactory functioning conditions.

Kanpur is not an exception to such scenario. By virtue of its geographic situation on the banks of Ganga river and Pandu river the city's sewerage system discharging in to either Ganga or Pandu 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 on account of deficient sewerage.
d) Need to meet the growth of the city- demographic growth as well as geographical growth

For the sewerage system Master Planning for a city having an old existing system, two distinct tasks must be taken in to account-

a) Rehabilitation/ Replacement of existing assets
b) Expansion of sewerage system

7.2 REHABILITATION OF EXISTING SEWERAGE SYSTEM

The primary reasons for the sewer rehabilitation is either to enhance the capacity or to increase the structural stability. The sewer runs through highly congested stretches of the city and for rehabilitation may requires extensive use of trenchless technology.

Rehabilitation as a process has to be meticulously 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-

a) Scientific approach to analysis of existing system
b) Use of proven techniques for condition assessment and system evaluation
c) Prioritising the implementation plan
d) Selection of appropriate method of trenchless technology.
e) Selection of a system to give durable end result having maximum lifecycle span.
f) Cost effectiveness
g) 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-

i) 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.

ii) The diagnostic study shall comprise of various phases like

1.Phase I: Information
2.Phase II: Investigations
  i. Hydraulic
  ii. Environmental
  iii. Structural
  iv. Operations and Management
3.Phase III: Develop solutions

iii) 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

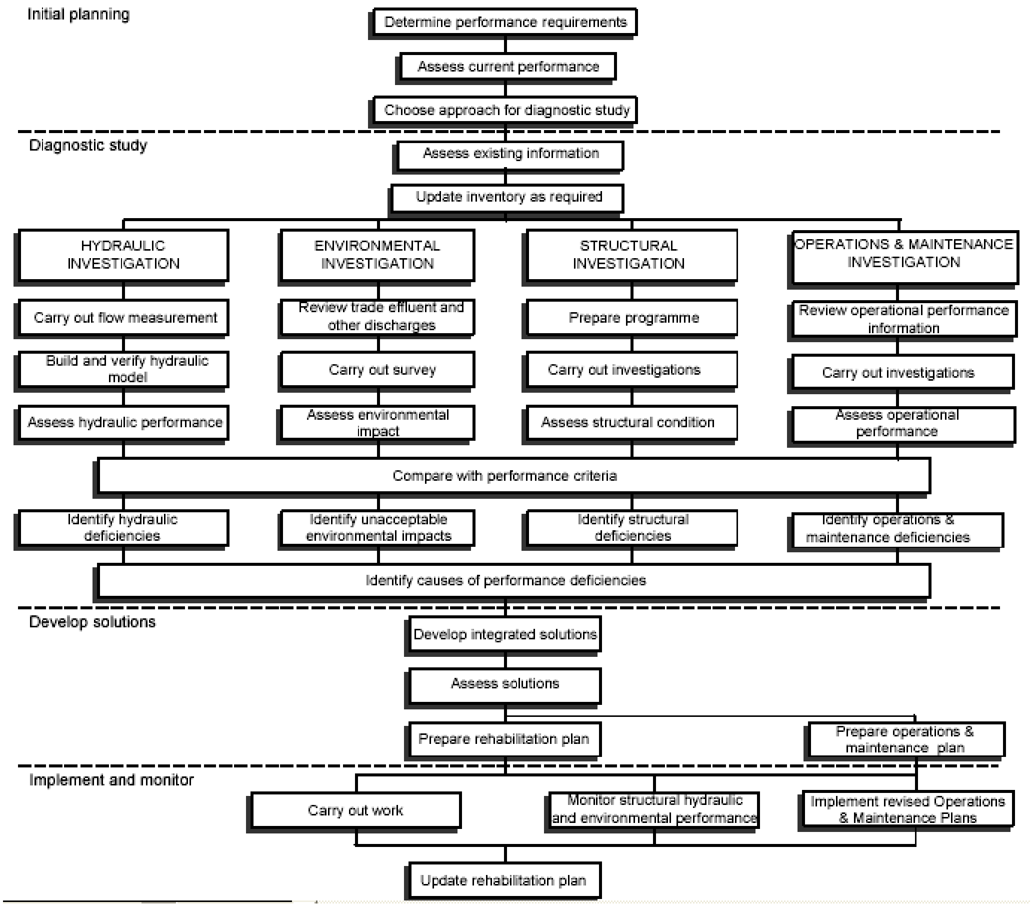


Figure 7.1 Stages in Sewer Rehabilitation

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

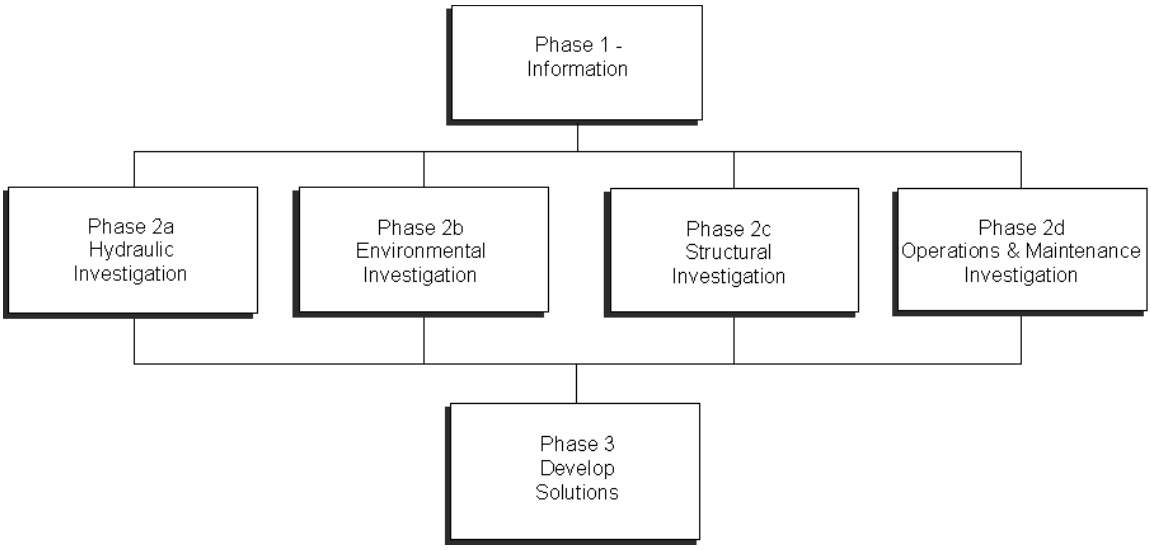
1) No information is available in degree of silting in the sewers in a properly quantified manner. It is learnt from enquiries that the degree of silting in these reaches varies from three fourths to half.

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
5) Some incidents of crown collapse are experienced during last two- three years.
6) No data on possible alignment shift between individual joints is available with the client
7) No data is available on settlement of individual pipes
8) Information on solidified deposits or root intrusions is not available
9) Systematic cleaning of the system in a planned manner has not been carried out in the past.
10) The slopes of the pipelines are reported to be in general satisfactory by UPJN. However since this affects the hydraulics of the system, it has to be re-ascertained for sample reaches in a scientific manner.
11) Previous CCTV inspection history is not known but most likely no CCTV inspection has been done in the past.
12) During inspection and rehabilitation work, the flows will have to be diverted through open drains, which lead to Ganga river. Though this is not advisable, possible means to overcome the issue of flow diversions shall have to be explored.

These basic observations on the system form the basis for formulation of rehabilitation/replacement strategy for the existing sewers.

7.2.2 Recommended approach

Systematic approach as enlisted earlier shall have to be adopted.



Stage 1: Initial Planning

As complete survey of sewerage system will be a 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. As general rule it is recommended to do sample condition assessment survey for a length of about 10 to 15% of the length of system. Since silting is badly affecting access to the sewers for direct inspection suitable preparatory steps must be taken to overcome this hurdle. It is recommended to do visual inspection of the entire system from ground/ road level by opening all manholes in a phased manner to get a preliminary idea of level of silting in the manhole and general flow conditions at various hours of the day. However, it must be borne in mind that preliminary visual observations in the manholes may not represent accurate picture about conditions in the sewer barrel. These observations would help in short listing

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 Investigations: 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 of time 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 as 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 there under shall have to be taken up so as to ensure consistency with legislative requirements.

iii) Structural Investigations: 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:

(1) Condition Assessment using

CCTV inspection

In this 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 lense, which gives 360 degree fisheye view of the sewer. The camera 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. The camera can float/ coast in partial sewage flow or can be crawler mounted for maneuverability. 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 that 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 Kanpur, 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.

CCTV inspection cost can range from Rs. 80/- per meter to about Rs. 125/- per meter besides the cost of desilting of the sewer.

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 SET- Sewer Evaluation Techniques with fuzzy logic and digital camera imaging. This provides ability to grade the sewers more rationally and at a faster speed.

(2) 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 5 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 identified stretches 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, especially Phool Bagh to Chabile Purwa.

A preliminary assessment for the sewers in District I and II is shown in Table 7.2.

Table 7.2 Preliminary Assessment of Sewers to be Rehabilitated

Sewerage District	**Stretches**	**From Down stream**	**To Upstream**	**Diameter (mm)**	**Length (m)**	**Preliminary remarks on condition/ accessibility**	**Recommendation**
District I	Phool bagh to Chhabile Purwa Meeting Point 84"	1D	1A	1500	5,180	Man entry size, Silting level very high at upstream ends	Physical inspection by man entry and logging of defects.
	GT road to Cantonment	1C	1B	2000	2,880		
	Tube well no.5 Cantt to Chhabile Purwa	1B	21B	2100	2,920		
	Chhabile Purwa to Jajmau CSPS (Jajmau A line)	1A	23A	2250	4,015		
District II	Chinyot Bhavan Govind Nagar to Harihar Nath Shastri Park	MH1	MH40	850	4,030	Non man entry size, Silting level very high at upstream ends	CCTV inspection must. Desilting needed to provide access for the camera.

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 only for preliminary guesswork and should not be taken as conclusive one.

iv) Develop solutions:

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

i Hydraulic factors:

This shall indicate if the existing sewer has adequate 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.

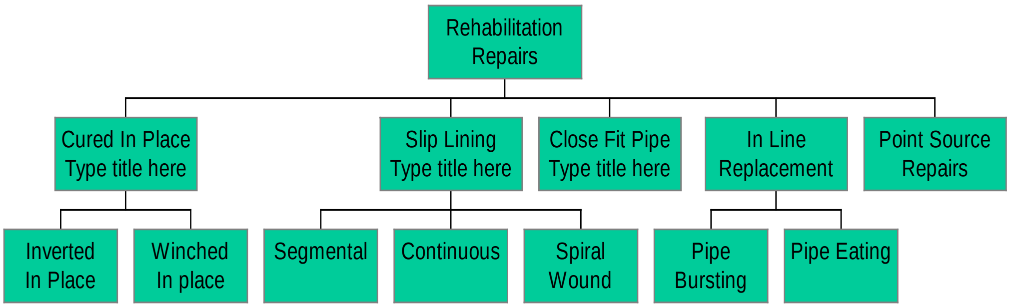
If only Hydraulic performance improvement is intended Type III lining would suffice. However, it will also be governed by other features like physical condition of joints. If major replacement is observed mere Type III lining would not be appropriate as it would require proper realigning and improvement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

Attention must be paid towards requirement of cross section are for the flow and the limits of reduction in cross section area. In general liner system reduce the cross section area and impacts 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 overall cost of the rehabilitation. The client must pay proper attention to the reduction in cross section area and capacity requirement and structural requirement.

v) Operation and Maintenance Factor:

Local organisations have developed their own strategy and system for the Operation and Maintenance system that largely takes into account the local technology and resources such as manpower. The solutions developed based on the rehabilitation strategy must provides a seamless change over from the conventional system to the system intended to be adopted at minimum cost and without unnecessarily affecting the existing O & M structure. At the same time the legacy system prevailing in the organisation may continue in operation in case of other sewers, which are not rehabilitated. Thus the stage may come when the legacy system as well as the advanced system would be working together and the O & M staff is required to be aware of co-existence of both the system. This demands capacity building with scientific approach and proper technology transfer.

7.2.3 Options for Rehabilitation Technology:



The options for technology 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.

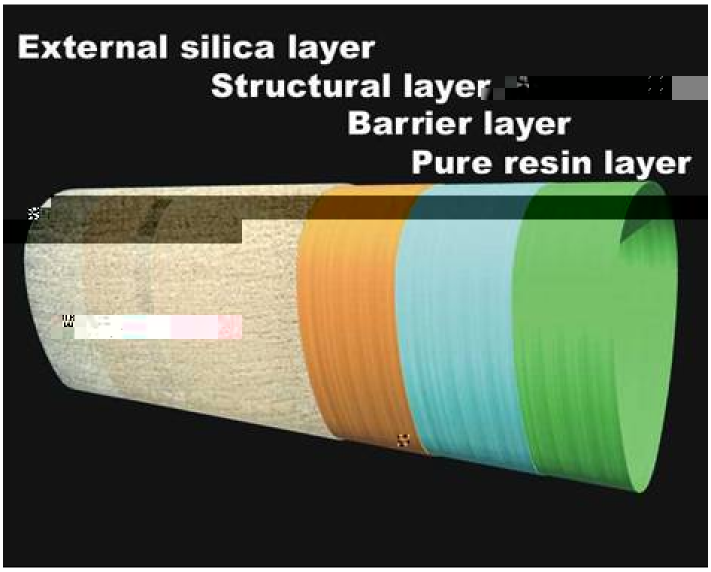
Various methods in above categories are described below

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 (Type 1) or Type 3- which is a non structural liner.

1) 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 type 4 as well. It is completely unsuitable for Grade 5 sewers.
2) 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’.

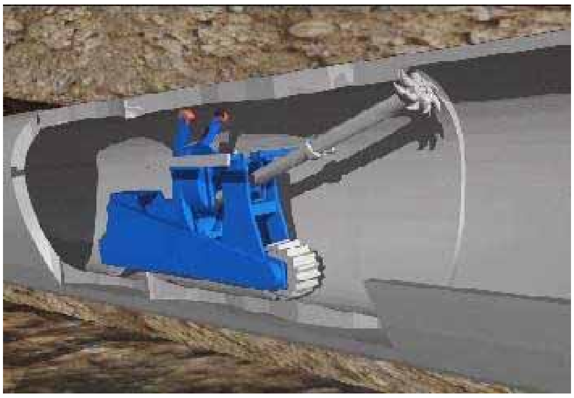


(1) Methods of Rehabilitation

The various methods of rehabilitation are:

- Sliplining with continuous or discrete pipe lengths
- Lining with cured in place pipes
- 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 Kanpur are described below-

Lining with reaming (slip lining): 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 ovoid 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.

Cured In Place lining: 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.

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 exist.

Selection of system of rehabilitation:

Selection of rehabilitation system is influenced by following factors:

i. Analysis of cause of defects
ii. Structural requirements
iii. Hydraulic considerations
iv. Flow capacity
v. Flow velocity
vi. Foundation condition
vii. Ground water table
viii. Accessibility of the site
ix. Traffic aspects along the road
x. Availability of technical know-how
xi. 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 Kanpur city, based on preliminary investigations, it appears that lining with GRP standalone sections and pipe bursting would be the most appropriate techniques for majority of the sewer network. Pipe bursting is generally used for small diameter sewers up to 450mm dia and hence GRP stand alone liners or CIPP seems appropriate for rehabilitation of sewers in Kanpur city. 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 (Table 7.3). New products and application technologies are continually being developed. The evaluation of each method should consider:

a. The type or types of problem
b. The physical characteristics of the structure such as the construction material
c. The condition and age
d. The location of the manhole with respect to traffic and accessibility
e. The risk of damage or injury associated with the current condition of the structure
f. The 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 7.3 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

For most rehabilitation/replacement work, it is necessary to bypass flow around the sewer that is being rehabilitated. 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 be deciding 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 Kanpur has 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 7.4 and 7.5.

Table 7.4 Technology wise Cost Estimate for Rehabilitation

From Downstream (Manhole Number)	**To Upstream (Manhole Number)**	**Diameter (mm)**	**Length (m)**	**Percentage of length considered for rehabilitation**	**Recommended method for rehabilitation**
District I					
1D	1A	1500	5,180	20	GRP liners with or without reaming
1C	1B	1980	2,880	20	
1B	21B	2100	2,920	20	
1A	23A	2250	4,015	90	
		Total	14,995		
District II					
1	40	838	4,030	40	GRP liners with or without reaming
		Total	4,030		

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./m)**	**Amount for Rehabilitation (Rs.)**
District I						
8,500	44,030,000	413	2,139,000	1,036.0	75,000	77,700,000
12,500	36,000,000	413	1,189,000	576.0	104,000	59,904,000
13,500	39,420,000	413	1,206,000	584.0	118,000	68,912,000
14,800	59,422,000	413	1,658,000	3,613.5	130,000	469,755,000
Total	178,872,000		6,192,000			676,271,000
District II						
4,400	17,732,000	413	1,664,000	1,612	52,000	83,824,000
Total	17,732,000		1,664,000			83,824,000

Table 7.5 Total Cost Estimate for Rehabilitation of Sewers

(Rs.)

Sr.	**Component**	**District I**	**District II**	**Total**
1	Amount for desilting	178,872,000	17,732,000	196,604,000
2	Amount for condition assessment	6,192,000	1,664,000	7,856,000
3	Amount for rehabilitation	676,271,000	83,824,000	760,095,000
	Total	861,335,000	103,220,000	964,555,000

CHAPTER 8

PRELIMINARY DESIGN OF AUGMENTATION / REHABILITATION OF OLD SEWAGE PUMPING STATIONS

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

This section of the F/S report describes the strategy for augmentation / rehabilitation of the old pumping stations in Kanpur.

8.1 PARMAT PUMPING STATION

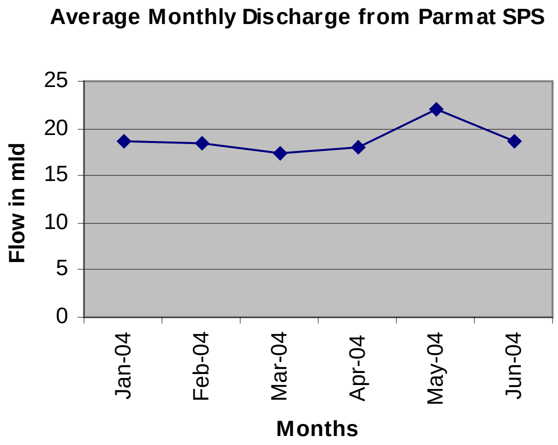
Parmat pumping station was constructed under Ganga Action Plan (GAP–I) to intercept wastewater from the Tafco nala, Parma ghat nala, Police lines nala, Jail nala. Under GAP II Sisamau the largest nala in Kanpur city will be diverted for treatment. Out of 138 mld, 80-100 mld will be tapped upstream and diverted to Bingawan STP. The remaining 30-50 mld will be tapped at Parmat pumping station and diverted to Jajmau STP.

8.1.1 Results of Inspection, Equipment (Inventory) Survey

Table 8.1 Specifications of the Parmat Pumping Station

	Item	Provision
1	Dimensions	There are two sumps viz. 4.8m dia circular sump and with depth 10.65m and other sump of dia 4.8m and depth 6.15
2	Installed capacity	1,884 lps
3	Installed pumps	3 x1250 HP – 22,000 lpm @ 10 m head 2 x 100 HP – 1,440 lpm @ 10 m head 2 x 50 HP – 1,440 lpm @ 10 m head
4	Diesel generating sets	1 x 200 kVA and 1x 250 kVA
5	2 Nos of rising main	600 mm dia and length is 1,000m 250 mm dia and length is 1,000m

The monthly average quantities of sewage pumped from this pumping station during the period January 2004 to June 2004 are presented in Figure 8.1.



8.1.2 Preliminary Inspection of Pumping Stations

All the four pumping stations, located along the bank of the river Ganga were visited to understand the existing situation of these pumping stations.

8.1.3 Observations of Parmat Pumping Station

As per survey of Parmat pumping station following salient points are given below: -

- All the pumps are very old and need to be replaced. These pumps were installed under Ganga Action Plan (GAP-I)
- Civil structure of pumping station requires minor repairs.
- One transformer of 110 KVA is not working which was installed in the year 1937
- The capacitor panel to improve the power factor of pumping stations is not available.
- Cable laying and support need to be improved.
- There is no spare feeder in L.T. panel.
- Several indication lamps on panels are either missing or not working.
- Earthing system is improper and requires improvements.
- There is not a single instrument to measure level, flow, pressure, temperature etc for proper operation.
- There is no mechanized screen (only wire mesh) available to screen the sewage water.
- There is no telecommunication provided at pumping station
- Skilled operation and maintenance staff is unavailable

8.1.4 Proposed Rehabilitation Programme For Parmat SPS

1) Out of two DG sets each of 200kVA and 250-kVA respectively, one DG set of 200kVA capacity is proposed to be shifted from Parmat PS to Nawab ganj PS. For Parmat PS 2 two new DG sets each of 40kVA with synchronization panel are proposed to meet the total standby power requirement of the SPS.
2) Presently there is one main 6.6 kV Oil Circuit Breaker panel which receives the power from KESA metering panel. This 6.6 kV power is further distributed to three individual 6.6 kV Oil Circuit Breaker panels. These three individual panels feed power to three 6.6kV/0.433kV indoor transformers of different capacities. The rating of the installed transformers is - 110kVA for pump house # 1,400kVA for pump house #2 and 250kVA for pump house # 3. Power stepped down to 0.433kV is fed to the Minimum Oil Circuit Breaker panel (MOCB) installed near the transformers. This power from the MOCB panel is again fed to the LT panel provided in the individual pump houses for that pump house load.
3) The no of switchgears involved in the existing system are very large and all the circuit breaker panels have served their lifetime service. To maintain these panels further is very time consuming and costly affair as availability of spares is very poor.
4) Instead of operating and maintaining so many outdated switch-gears / transformers, one new 6.6kV Vacuum Circuit Breaker panel, with one incomer and two outgoing transformer feeders, is proposed which will receive the power from the KESA metering panel.
5) The existing transformers of different capacities are proposed to be replaced by two new outdoor transformers of 800kVA. Each transformer shall be rated for full working load of the plant. Normally each transformer shall be loaded to about 50 % of its capacity). This will ensure the running of the stand by pump in addition to normal working pumps in the event of compensating the loss of pumping, followed by a prolonged power failure.
6) Presently there are three Minimum Oil Circuit Breaker panels, whose function is just to receive the stepped down power from transformers and transmit it to the individual LT

panel located in the respective pump houses. All these individual panels with MOCB are proposed to be replaced by new Main Electrical Panel (MEP) with Air Circuit Breakers with a facility of bus-coupler and adequate interlocking. This new panel shall feed power to the three LT panels located in three pump houses.

7) Entire pumping station is running without any power capacitor to compensate reactive power, which if not compensated by providing adequate power capacitor, will result in increased power losses in the system and ultimately increased power bills. To compensate the reactive power, two capacitor control panels (one on each bus of the MEP) with adequate rating of capacitors and automatic power factor correction relay are proposed. These two panels shall be located near the MEP in the main panel room.
8) The existing LT panels provided for each pump house, which cater supply to the pump starters, are with MOCB/switch fuse units of British make. Availability of spares for these switch-gears is very poor and hence all these panels as well as oil filled starters are proposed to be replaced by new LT panels with Air Circuit Breakers / Moulded Case Circuit Breakers and starter module for each pump in the panel itself.
9) All the cables from LT starter panel to pump motors are proposed to be replaced by new cables.
10) Existing indoor as well as outdoor lighting system is not working; hence entire new lighting system is proposed.
11) There is no earthing system provided for the electrical system. Hence the entire new earthing system with adequate size of earthing conductor is proposed.
12) Manual screen replacement in existing sumps
13) New rising main for additional sewage flow (1600 m length dia 1100.00mm)
14) Minor repairs in civil structure, painting.

8.1.5 Additional Pumping Station at Parmat

In order to take care of additional sewage flow, in addition to existing pumping facility it is proposed to construct an additional sewage pumping station for the flow of 50 mld.

This proposed pumping station consist of the following units

- New screen channel
- Wet well and dry well
- MEP room
- D.G room

Submersible type centrifugal pumps have been proposed at this SPS.

(1) Receiving Power Provision for New Proposed PS at Parmat

Power for new pumping station is proposed to be tapped from the proposed new HT VCB panel for existing plant as 2 points of supply in the same premises are not permitted.
The cost of HT switchgear required to feed HT power to transformers for new PS, is considered in the rehabilitation cost of existing pumping station.

(2) Pumping station details for additional pumping station at Parmat

Table 8.2 Pumping Station Details for Additional Pumping Station at Parmat

Sr.	Item	Provision
1	Pumps for year 2015	Six nos 28.13 mld, @17.55 m head (120 HP where, four nos are working and two nos are stand by)
	Pumps for year 2030	Six nos 28.13 mld, @17.55 m head (120 HP, where four are working and two are stand by)
2	Rising main	One no. 1000 mm dia Pre stressed concrete pipe, 1,600 m length (m)
3	Coarse screen channel (40 mm clear spacing)	2 nos 2.0 m x 5.0 m
4	Medium screen channel (20 mm clear spacing)	2 nos 2. 0m x 5.0m
5	Wet well	1 nos 18m x 5.5 m, detention time is 3.75 min
6	Valve chamber	1 nos 18m x 6.0m

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

The plan and profile of the rising main are presented in drawing KAP-PP-PH_1-TO 3.

(3) Allied Buildings

In addition to the above, following buildings are proposed 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 for Parmat Pumping Station

Sr.	Item	Size (m)
1	MEP building	6 x 4
2	DG room & control room	8 x 6
3	Transformer yard	6 x 8

8.1.6 Cost Estimates for New Pumping Station at Parmat

Budgetary cost estimation of sewage pumping stations was carried out considering prevailing market rates and applicable schedule of rates. Estimated capital cost and operation & maintenance cost of the pumping station is given below.

(1) Civil Cost

Table 8.4 Capital Civil Cost for Parmat Pumping Station

Sr.	Item	Cost (Rs.)
1	Inlet, screen channels, wet well	3,934,000
2	MEP building	144,000
3	DG room / control room	288,000
4	Transformer yard	35,000
	Total	4,401,000

(2) Mechanical Cost

Table 8.5 Capital Mechanical Cost for Parmat Pumping Station

Sr.	Item	Cost (Rs.)
1	Coarse screen	150,000
2	Screen channel gates	260,000
3	Mechanical screens	850,000
4	Manual screens	75,000
5	EOT for pumps	250,000
6	EOT for screens	200,000
7	Pumps	11,770,000
8	Piping and valves	2,000,000
9	Conveyor belt	450,000
	Total	16,005,000

(3) Electrical and Instrumentation Cost

Table 8.6 Capital Electrical and Instrumentation Cost for Parmat Pumping Station

Sr.	Item	Cost (Rs.)
1	Panels	10,713,000
2	Cables	634,000
3	Earthing and safety equipment	217,000
4	Lighting	151,000
5	Instrumentation	1,023,000
	Total	12,738,000

(4) Rising Main

Table 8.7 Capital Rising Main Cost for Parmat Pumping Station

Sr.	Item	Cost (Rs.)
1	PSC pipe	7,435,000
2	Appurtenances	300,000
3	Excavation	480,000
4	Miscellaneous (crossing / encasement)	100,000
	Total	8,315,000

8.1.7 Operation & Maintenance Cost of additional PS at Parmat

Table 8.8 Operation and Maintenance Cost for Parmat Pumping Station

Sr.	Item	Cost (Rs.) per annum
1	Manpower cost	766,000
2	Power cost (20 hrs @ Rs. 3.25/kWh)	3,921,000
3	Diesel cost (4 hrs @ Rs. 34/liter)	2,469,000
4	Maintenance of civil works @ 1.5 %	66,000
5	Maintenance of M&E works @ 3 %	862,000
6	Maintenance of rising main @ 0.25 %	21,000
	Total annual O & M cost	8,105,000

Power cost depends on peak flow

8.1.8 Abstract of Costs for Additional PS at Parmat

Table 8.9 Abstract of Cost Estimates for Parmat Pumping Station

Sr.	Item	Cost (Rs.)
1	Civil cost	4,401,000
2	Mechanical cost	16,005,000
3	Electrical & instrumentation cost	12,738,000
4	Rising main cost	8,315,000
	Total capital cost	41,459,000

Table 8.10 Cost Estimates for Rehabilitation of Existing Parmat Pumping Station

Sr	PS Location	Civil	Mechanical (screens)	Electrical (panels, cables, lighting earthing)	Total Capital Cost (Rs.)	O and M cost @1.5 for Civil works and @3%, for Mechanical and Electrical works
1	Parmat pumping station	60,000	150,000	22,695,336 (without power charges) 25,195,336 (with power charges)	25,405,000	761,000 per annum
		Total cost for pumping station (Rs.)			25,405,000	

8.2 NAWAB GANJ PUMPING STATION

Nawab ganj pumping station was implemented under the Ganga Action Plan (GAP–I) to intercept wastewater from the following nalas: Kesa colony nala, roadways, colony nala, Jageswar nala Jewra nala, Nawab ganj nala, and Rani ghat nala. The pumping station also collects wastewater from local sewers. Based on the flow measured in the contributing nalas the Study Team has estimated the required capacity as 4.2 mld. However, a flow of 12.9 mld was reported by UPJN in 1997. An in between value is recommended in the M/P and the expected flows are 6 and 8 mld in 2015 and 2030.

8.2.1 Results of Inspection, Equipment (Inventory) Survey

Table 8.11 Specifications of the Nawab Ganj Pumping Station

Item	Provision
Dimensions	There are two sumps viz 4.8m dia circular sump and depth is 5.4m and other sump is 6m dia and depth 6.75 m
Installed capacity	350 lps
Installed pumps	1 x 40 HP – 6,162 lpm @ 10 m head 2 x 30 HP – 4,950 lpm @ 10 m head 2 x 15 HP – 2,475 lpm,@ 10 m head
Diesel generating sets	1 x 110 kVA
Rising main	Dia of 450 mm and length is 1,500m

The monthly average quantities of sewage pumped from the pumping station during the period January 2004 to June 2004 are presented in Figure 8.2.

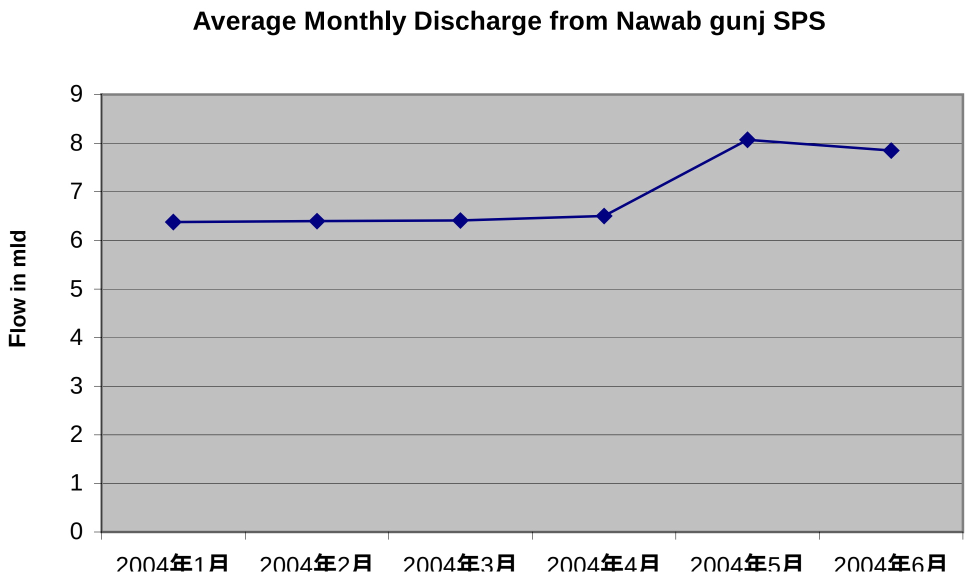


Figure 8.2 Average Monthly Discharge from Nawab Ganj SPS

8.2.2 Observation of Nawab Ganj Pumping Station

As per survey of Nawab ganj pumping station following salient points are given below: -

- All the pumps are very old and need to be replaced. These pumps were installed under Ganga Action Plan (GAP-I)
- 15 HP pumps are out of order.
- Civil structure of pumping station required minor repair.
- There is no standby transformer
- Alternative power supply (110kVA-Diesel generator) is available. However, there is no standby generator set.
- One outgoing feeder of DG set electrical panel is burned. Therefore both pump houses are connected with single outgoing feeder.
- The capacitor panel to improve the power factor of pumping stations is not available.

8.2.3 Proposed Rehabilitation Programme For Nawab Ganj SPS

1) Replacement for manual screens of two existing sumps.
2) New rising main of dia 450 mm for total length of 1,100 m (plan and profile of this rising main are presented in drawing KAN-PP-NC-1).
3) Existing DG set of 110kVA is not adequate to run all the pumps in both the pump houses. Hence one 200 kVA DG set from Parmat PS is proposed to be shifted to Nawab ganj PS. This DG set will take care of the entire working load of both the pump houses.
4) One change over switch is installed which receives power from KESCO metering panel and 110kVA DG set. Outgoing supply of this changeover switch is fed to two LT panels installed in each pump house by laying two cables for two panels from the same terminals. Hence one new Main Electrical Panel is proposed which will receive power from KESCO metering panel and 200kVA DG set.
5) Presently there is no provision of power capacitors and hence one new capacitor control panel with adequate banks of capacitors and automatic power factor correction relay is proposed in the existing change over panel room.
6) Existing indoor as well as outdoor lighting system is not working; hence entire new lighting system is proposed.
7) Minor repairs in civil structure viz. painting

8.2.4 Abstract of Cost Estimates

Table 8.12 Cost estimates for Rehabilitation of Nawab Ganj Pumping Station

Sr	**PS Location**	**Civil**	**Mechanical (screens)**	**Rising Main**	**Electrical (panels, cables, lighting earthing)**	**Total Capital Cost (Rs)**	**O and M cost @1.5 for Civil works and 3%, for mechanical and electrical works and for rising main @ 0.25%**
1	Nawab Ganj SPS	60,000	150,000	5,780,000	1,613,820	7,603,820	68,265 per annum
		Total cost for pumping station (Rs.)				7,604,000	

8.3 MUIR MILL SPS

This pumping station was constructed under the Ganga Action Plan (GAP-I) to intercept sewage flowing in Muir mill nala. The flow measured by the Study Team in 2003 was 3.13 mld whereas 4.54 mld was reported by UPJN in 1997.

8.3.1 Results of Inspection, Equipment (Inventory) Survey

Table 8.13 Specifications of the Muir Mill Pumping Stations

Muir Mill SPS	
Dimensions	Rectangular sump size is 6m.x 4m x 7m
Installed capacity	140 lps
Installed pumps	3 x 25 HP – 2,800 lpm @ 15 m head
Diesel generating sets	1 x 75 kVA
Rising main	400 mm dia and length is 735 m

The monthly average quantities of sewage pumped from thee pumping station during the period January 2004 to October 2004 are presented in Figure 8.3.

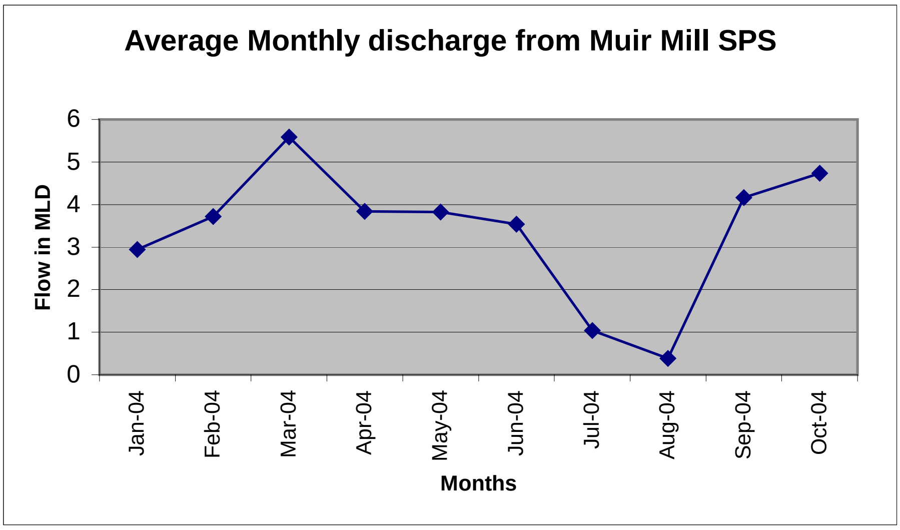


Figure 8.3 Average Monthly Discharge from Muir Mill SPS

8.3.2 Observations of Muir Mill Pumping Station:

As per survey of Muir mill pumping station following salient points are given below: -

- All the pumps are submersible and working in good condition.
- There is no standby transformer
- Alternative power supply (75kVA-Diesel generator) is available. However, there is no standby generator set.
- The capacitor panel to improve the power factor of pumping station is not available.
- Cable laying and supports are OK.
- Electrical panel is in good condition.
- There is not a single instrument to measure level, flow, pressure, temperature etc for proper operation.
- There is no mechanized screen (only wire mesh) available to screen the sewage water.
- There is no telecommunication provided at pumping station
- Skilled operation and maintenance staff is unavailable.

8.3.3 Proposed Rehabilitation Programme For Muir Mill SPS

1) The existing panel is in working condition except the required capacitor units of adequate ratings. Hence one capacitor unit across each motor is proposed, which shall be connected directly across the feeder terminals inside the panel.
2) The lighting system (indoor as well as outdoor) is inadequate and in non-working condition. Hence entire new lighting system is proposed.
3) There is no earthing system provided for the electrical system. Hence the entire new earthing system with adequate size of earthing conductor is proposed.
4) Provision for mechanical screen.

8.3.4 Abstract of Cost Estimates

Table 8.14 Cost Estimates for Rehabilitation of Pumping Station

Sr	PS Location	Mechanical (screens)	Electrical (panels, cables, lighting earthing)	Total Capital cost (Rs.)	O and M cost @1.5 for Civil works and 3%, form mechanical and electrical works
1	Muir Mill SPS	150,000	329,070	479,070	14,373 per annum
		Total Capital cost (Rs.)		479,000	

8.4 GUPTAR GHAT PUMPING STATION

This pumping station was constructed under the Ganga Action Plan (GAP-I) to intercept sewage. The present condition of this pumping station has been assessed and the same is reported in this section.

8.4.1 Results of Inspection, Equipment (Inventory) Survey

Table 8.15 Specifications of the Guptar Ghat Pumping Stations

Guptar Ghat Pumping Station	
Dimensions	Circular sump dia 5.0 m dia and depth is 7 m
Installed capacity	167 lps
Installed pumps	3 x 15 HP – 1,000 lpm @ 15 m head
Diesel generating sets	1 x 50 kVA
Rising Main	150 mm dia and 300 m length

The monthly average quantities of sewage pumped from the pumping station during the period January 2004 to October 2004 are presented in Figure 8.4.

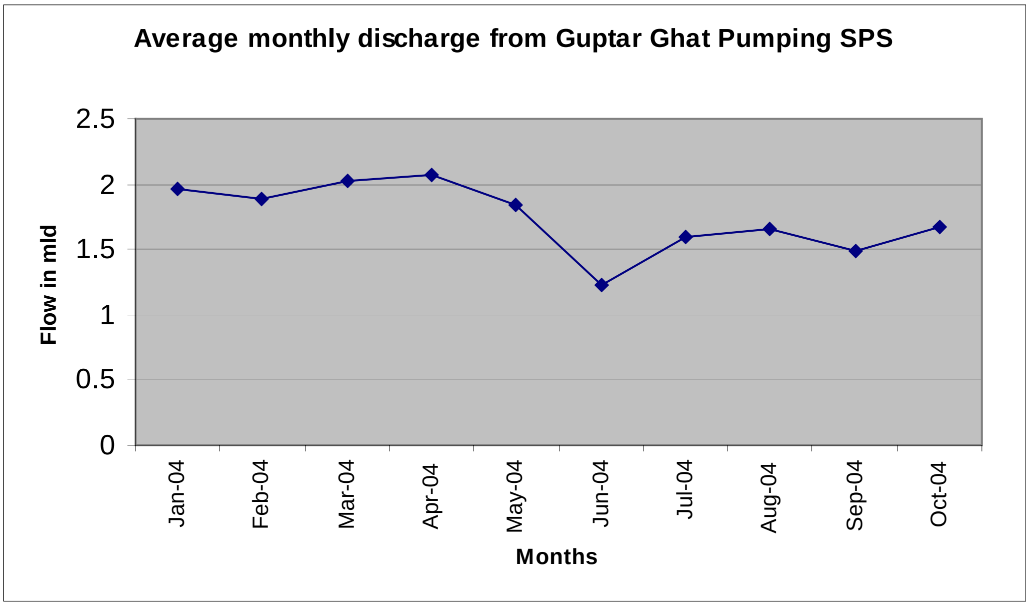


Figure 8.4 Average Monthly Discharge from Guptar Ghat Pumping Station

8.4.2 Observations of Guptar Ghat Pumping Station:

As per survey of Guptar ghat pumping station following salient points are given below: -

- All the pumps are very old and need to be replaced. These pumps were installed under Ganga Action Plan (GAP-I)
- Civil structure of pumping station require minor repairs.
- There is no separate transformer for pumping station.
- Alternative power supply (50kVA-Diesel generator) is available. However, there is no standby generator set.
- The capacitor panel to improve the power factor of pumping station is not available.
- Cable laying and support need to be improved.
- There is no spare feeder in L.T. panel.
- Several indication lamps on panels are either missing or not working.
- Earthing system is improper and requires improvements.
- Outdoor lighting system is improper and requires improvements.
- There is not a single instrument to measure level, flow, pressure, temperature etc for proper operation.
- There is no mechanized screen (only wire mesh) available to screen the sewage water.
- There is no telecommunication provided at pumping station
- Skilled operation and maintenance staff is unavailable.

8.4.3 Proposed Rehabilitation Programme For Guptar Ghat SPS

1) The existing panel is in working condition except the required capacitor units of adequate ratings. Hence one capacitor unit across each motor is proposed which shall be connected directly across the motor terminals.
2) The lighting system (indoor as well as outdoor) is inadequate and in non-working condition. Hence entire new lighting system is proposed.
3) There is no earthing system provided for the electrical system. Hence the entire new earthing system with adequate size of earthing conductor is proposed.
4) Minor repairs in civil structure, painting.

8.4.4 Abstract of Cost Estimates

Table 8.16 Cost Estimates for Rehabilitation of Guptar Ghat Pumping Station

Sr	PS Location	Civil	Electrical (panels, cables, lighting earthing)	Total Capital Cost (Rs.)	O and M cost @1.5 for Civil and 3%, for mechanical and electrical works
1	Guptar ghat SPS	60,000	232,195	292,195	7,866 per annum
	Total cost for pumping station (Rs.)			292,200	

8.5 LAKHANPUR PUMPING STATION

At present the pumping station at Lakhanpur is not utilized and the assets in this pumping station are obsolete. It is proposed to rehabilitate this pumping station as a whole. Further, the capacity of this pumping station has to be augmented to take care of additional sewage flow from Makrikhera nala and a colony located near the existing pumping station at Lakhanpur.

8.5.1 Design flow

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

Table 8.17 Design Flow of Lakhanpur Sewage Pumping Station

Sr.	Pumping Station	Sewage Flow (mld)	
		2015	2030
1	Lakhanpur pumping station	20	40
	Peak factor as per the CPHEEO Manual	2.25	2.25

8.5.2 Unit sizes for Lakhanpur Pumping Station

Submersible type centrifugal pumps have been proposed at this pumping station.

Table 8.18 Details of Lakhanpur Pumping Station

Sr.	Item	Provision
1	Pumps for year 2015	3 nos. 15 mld @ 16.86m head (100 HP, where two are working and one is standby), (40 HP, where one is working and one is stand by) 2 nos. 10 mld @16.86 m head (150 HP, where two are working and one is standby), (75 HP, one is working and one is stand by)
	Pumps for year 2030	3 nos. (Additional), 15 mld @ 16.86m head 2 nos. (Additional),10 mld @16.86 m head
2	Rising main	1 No. 600 mm dia CI pipe 650 m length
3	Coarse screen channel (40 mm clear spacing)	1 No. 6 x 2.20m
4	Medium screen channel 920 mm clear spacing)	2 No. 6 x 2.20m(1 mechanical and 1 manual)
5	Wet well	1 no. 15m x 8m and detention time is 3.75 min
6	Valve Chamber	1 no. 15m x 4.25 m

The layout drawing of the pumping station is presented in KAN-PS-LKP-1. General arrangement of the pumping station is presented in drawing KAN-PS-LKP-2.The plan and profile of the rising main is presented in drawing KAP-PP-MP-RM1-2.

8.5.3 Allied Buildings

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

Table 8.19 Details of Allied Buildings at Lakhanpur Pumping Station

Sr.	Item	Size (m)
1	MEP building	6 x 4
2	DG room & control room	8 x 6
3	Transformer yard	7 x 5
4	4 pole structure	8 x 6

8.5.4 Capital Cost for Lakhanpur Pumping Station

Budgetary cost estimation of sewage pumping stations has been carried out considering prevailing market rates and applicable schedule of rates. Estimated capital cost and operation & maintenance cost of the pumping station is given below.

8.5.5 Civil Cost

Table 8.20 Capital Cost of Civil Works at Lakhanpur Pumping Station

Sr.	Item	Cost (Rs.)
1	Inlet, screen channels, wet well	8,532,000
2	MEP building	144,000
3	DG room / control room	288,000
4	Transformer yard	35,000
5	Staff quarter	1,231,000
6	4 pole structure	48,000
	Total	10,278,000

8.5.6 Mechanical Cost

Table 8.21 Capital Cost of Mechanical Works at Lakhanpur Pumping Station

Sr.	Item	Cost (Rs.)
1	Coarse screen	150,000
2	Screen channel gates	260,000
3	Mechanical screens	1,250,000
4	Manual screens	75,000
5	EOT for pumps	250,000
6	EOT for screens	200,000
7	Pumps (100 HP)	3,923,000
	Pumps (40 HP)	1,526,000
8	Piping and valves	2,000,000
9	Conveyor belt	450,000
	Total	10,084,000

8.5.7 Electrical and Instrumentation Cost

Table 8.22 Capital Cost of Electrical and Instrumentation Works at Lakhanpur Pumping Station

Sr.	Item	Cost (Rs.)
1	Provision for grid power supply	5,370,000
2	Panels	9,736,000
3	Cables	1,098,000
4	Earthing and safety equipment	250,000
5	Lighting	170,000
6	Instrumentation	885,000
7	Miscellaneous	114,000
	Total	17,623,000

8.5.8 Rising Main

Table 8.23 Capital Cost of Rising Main at Lakhanpur Pumping Station

Sr.	Item	Cost (Rs.)
1	CI Class B pipe	4,924,000
2	Appurtenances	300,000
3	Excavation	98,000
4	Miscellaneous (crossing / encasement)	100,000
	Total	5,422,000

8.5.9 Abstract of Costs for Lakhanpur Pumping Station

Table 8.24 Abstract of Cost Estimates for Lakhanpur Pumping Station

Sr.	Item	Cost (Rs.)
1	Civil cost	10,278,000
2	Mechanical cost	10,084,000
3	Electrical & instrumentation cost	17,623,000
4	Rising main cost	5,422,000
	Total capital cost	43,407,000

8.5.10 Operation & Maintenance Cost for Lakhanpur Pumping Station

Table 8.25 Operation and Maintenance Cost Estimates for Lakhanpur Pumping Station

Sr.	Item	Cost (Rs.) per annum
1	Manpower cost	515,000
2	Power cost (20 hrs @ Rs.3.25/kWh)	1,416,000
3	Diesel cost (4 hrs @ Rs. 34/liter)	823,000
4	Maintenance of civil works @ 1.5 %	154,000
5	Maintenance of M&E works @ 3 %	831,000
6	Maintenance of rising main @ 0.25 %	14,000
	Total annual O & M cost	3,753,000

Power cost depends on peak flow