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 III MASTER PLAN FOR PROJECT CITIES

VOLUME III-3 SEWERAGE MASTER PLAN FOR ALLAHABAD CITY

JULY 2005

TOKYO ENGINEERING CONSULTANTS CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.

GE
JR
05-038

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 III MASTER PLAN FOR PROJECT CITIES

VOLUME III-3 SEWERAGE MASTER PLAN FOR ALLAHABAD CITY

JULY 2005

TOKYO ENGINEERING CONSULTANTS CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.

Foreign Exchange Rate:

Master Plan
US$ 1 = JPY 109.09
US$ 1 = Rs 45.33
(As of March 2004)

Feasibility Study
US$ 1 = JPY 103.66
US$ 1 = Rs 43.70
(As of February 2005)

FINAL REPORT

ON

WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER

JULY 2005

GENERAL TABLE OF CONTENTS

VOLUME III-3

SEWERAGE MASTER PLAN FOR ALLAHABAD CITY

Table of Contents

List of Tables

List of Figures

Abbreviations

Glossary of Terms

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX

A1 Ministry of Surface Transport: letter-RW/WH/12016/105 95/N/U.P. dated 13/3/96

A2 Ministry of Surface Transport: Letter no. NH/12016/105 95 N-U.P. dated 9/04/99

A3 North Eastern Railway, letter no. W/410/1/BSB/W1 dated 23/26/4/1980

B Cost Comparison of Alternatives

C Drawings

- C1 1995 Sewerage Master Plan
- C2 UPJN GAP-II Proposed STP and Nala Tapping
- C3 Naini STP: Process Flow Diagram
- C4Naini STP: Site Plan for Augmented Capacity
- C5 Salori STP: Process Flow Diagram
- C6 Salori STP: Site Plan
- C7 to C13 Trunk Sewers and Laterals
- C14 to C20 Trunk Sewers and Laterals (Long Section)

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
FS	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
MP	Maturation Pond / 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 received 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 Liquor 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 which 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

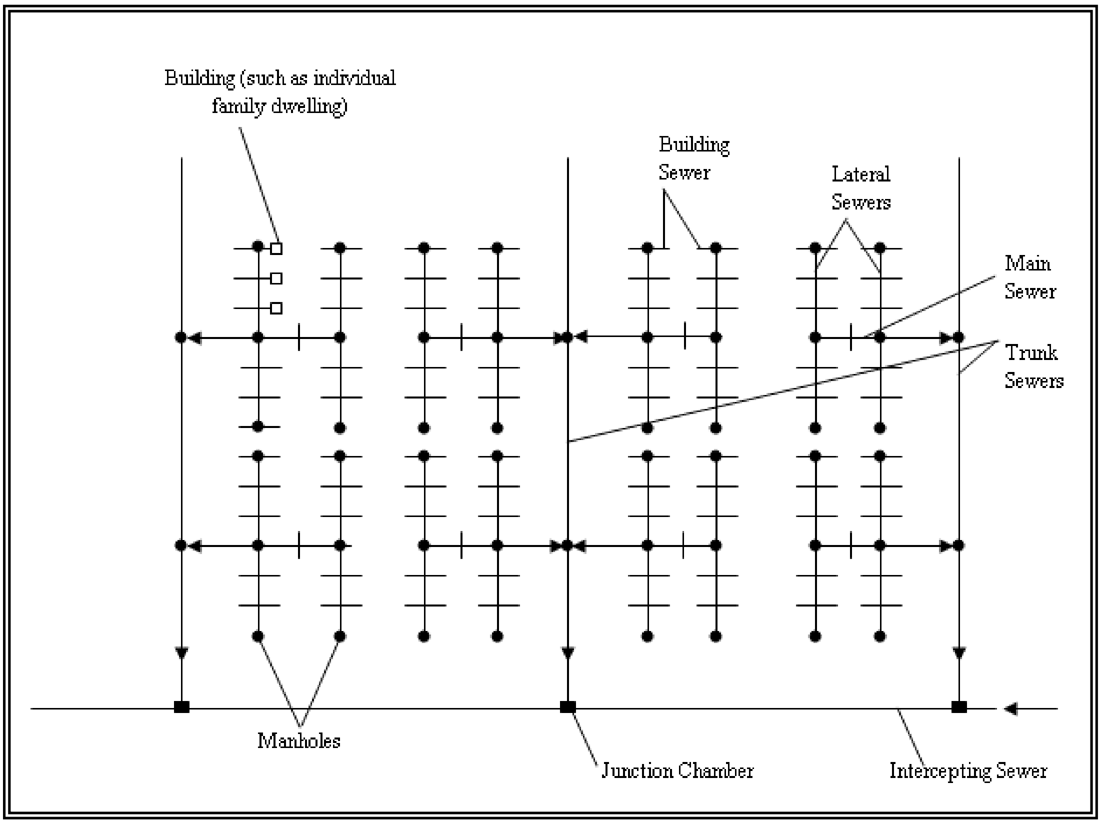
1. ***Interceptor Sewer:*** A sewer that receives flow from a number of other sewers or outlets for disposal or conveyance to a treatment plant.

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

3. ***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.

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

5. ***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 a main sewers.



CHAPTER 1

EXECUTIVE SUMMARY

CHAPTER 1 EXECUTIVE SUMMARY

1.1 GENERAL

This is the Master Plan report for pollution control and sewerage development in Allahabad city. The initial stage of this study has examined prospective urban development to the year 2030, evaluated alternative sewerage projects, and selected the priority components for the Feasibility Study (FS) which has been carried out in subsequent stage.

The methodology of this study has been to determine the least cost approach for meeting Allahabad city's sewerage and pollution control needs. This has involved the consideration of existing infrastructure and proposals by UPJN for GAP-II, alternative service coverages, alternative technologies, and alternative wastewater treatment and disposal methods.

Allahabad city's population is projected to double from 1.1 million in 2003 to 2.08 million by 2030. A summary of relevant population, water supply and wastewater data is presented in Table 1.1.

At present the total domestic wastewater load is about 226 mld vs. an installed treatment capacity of 60 mld. The amount of wastewater collected and diverted to treatment is on average 66 mld. Remaining wastewater is discharged to Ganga and Yamuna rivers through open drains. The Yamuna river joins the Ganga at the Sangam confluence, a site that has great spiritual significance for the Hindu faithful. It is used daily for ritualistic bathing and by the multitudes during perennial Melas including the Kumbh Mela which sees the assembly of millions of pilgrims every 10 years. UPJN is at present implementing the construction of a 29 mld sewage treatment plant using FAB technology to treat flows at the tail end of Salori nala which discharges directly upstream of the Sangam confluence.

Water supply and sanitation services are inadequate for Allahabad’s present population. The installed raw water treatment capacity is 130 mld, while the total production from all sources is 271 mld, corresponding to 207 lpcd. Water supply is intermittent, and adverse sanitary conditions (including defecation in the open) cause increasing hazards to public health.

The sewer infrastructure is old, and poorly maintained. Many of the existing trunk sewers do not have sufficient hydraulic capacity for projected wastewater loads. Growth is occurring to the West around Lukerganj between Ghaghar nala and Sasur Khaderi. Growth is also occurring to the North in the Rajapur and Salori nala catchments and South across the Yamuna river. Given the geographical constraints and difficulties in crossing the two rivers it will not be possible to consolidate collection and treatment to centralized facilities. A number of smaller decentralized schemes is proposed under the present Master Plan.

Table 1.1 Project Data Sheet, Allahabad

(1) Population

	2003	2015	2030
Municipal	1,039,429	1,390,856	1,913,712
Outside municipal boundary	51,382	85,662	143,721
Floating	10,394	13,909	19,137
Total	1,101,205	1,490,427	2,076,570

(2) Water Supply

		2003	2015	2030
Population served by municipal system		1,049,800	1,404,700	1,932,850
Demand	mld	210	290	402
Water supply treatment capacity				
Existing	mld	130	130	130
Proposed	mld		10	10
Total	mld	130	140	140
Water source				
Municipal-river	mld	80	140	140
Municipal-wells	mld	137	137	137
Private	mld	54	54	54
Other	mld	-	-	-
Total	mld	271	331	331

(3) Wastewater

		2003	2015	2030
Total population		1,101,205	1,490,427	2,076,570
Population in sewer service area		308,340	596,170	1,661,300
Population connected to sewer		200,494	454,885	1,530,827
Percentage of connected population		18 %	31 %	74 %
Wastewater return rate per capita	lpcd	205	175	155
Total wastewater generation	mld	226	261	322
Amount intercepted	mld	60	226	322
Treatment capacity				
Existing	mld	60	60	60
Sanctioned	mld		29	29
Proposed	mld		160	251
Total	mld	60	249	340

1.1.1 Need for a Sewerage Master Plan

The GAP projects and proposals have focused on reducing pollution loads by diverting sewage at the tail end of drains during dry weather only. GAP does not address the need for removing sewage from the drains to prevent pollution during wet weather. Nor does it address issues of public health and sanitation within the city.

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

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

Diversion facilities constructed under GAP are not designed to operate during wet weather, therefore the use of open drains for wastewater disposal will remain a significant source of pollution during wet weather.

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

1.1.2 Key Issues for the Implementation of Sewerage Master Plan

1) Adopting a decentralized approach

The Sewerage Master Plan divides the urban centre into sewerage districts. A decentralized approach has been favoured to minimize conveyance costs and reduce the size of sewerage facilities. Smaller treatment works will simplify site selection and land acquisition. Furthermore, it is generally easier to manage the operation and maintenance of smaller facilities.

2) Coordinating development of branch sewers with trunk sewers

The trunk facilities identified in the Master Plan are the backbone of the sewerage system. It will open the way for extending the branch sewer network into parts of the city that are not presently served. It is essential that existing and future development areas be connected to this backbone in order achieve water quality, health and sanitation objectives. JAL Sansthans, and Nagar Nigams must implement programs for improving and extending the branch sewer system. A concentrated effort will be required to connect existing and future growth areas, else the trunk sewer system will fail because there will be insufficient wastewater to achieve self-cleansing velocities.

3) Adopting and adhering to the Sewerage Master Plans

The Master Plans for sewerage must be formally adopted by the authorities responsible for the development of cities. A formal mechanism is required to make it mandatory for Development Authorities and Housing Boards to adhere to the Master Plan. Continuing in the present mode whereby new colonies are developed without proper outlet to trunk sewer facilities will only add to the drainage and pollution problems of the city.

4) Cost sharing for trunk facilities: user pay principle

Implementation of new developments must proceed in a planned manner. Major trunk facilities should be extended to service planned communities. In keeping with the user pay principle, it should be made mandatory by law for developers, whether private or Government to share in the cost of trunk sewers and treatment plant.

5) Land acquisition for future facilities

Land identified for sewage treatment works and pumping stations must be acquired as soon as possible and reserved for the future development of the sewerage system. Similarly, right of way and maintenance easements are required along trunk sewer alignments to prevent encroachment.

6) Power cuts

Pumping stations and treatment plants must be provided with a reliable and continuous power supply. These facilities must be designated as essential services and should be given top priority for service by the electrical utility. Emergency power generators must be provided at all facilities and funding for fuel must be guaranteed to prevent overflows of untreated sewage.

1.2 OVERVIEW OF THE MASTER PLAN

A number of alternative district layouts have been evaluated and a recommended plan is presented in Section 7. The proposed sewer service areas and sewerage districts for 2030 are presented in, Figure 7.2.

The sewerage Master Plan is developed for areas within the greater limits of the Municipal Corporation (as defined by the Development Authority) that have or will have population densities greater than 120 persons per hectare. Approximate population densities based on a visual interpretation of land use are derived from satellite images.

The city of Allahabad has been divided into 8 sewerage districts. Each sewerage district having it's own sewage treatment works.

(mld)

STP	District	Status	2003	2015	2030
Naini STP	A	E/A	60	80	80
Numaya Dahi STP	B	P	-	50	50
Salori STP	C	S/A	-	29	35
Rajapur STP	D	P	-	65	80
Kodara STP	E	P	-	15	30
Ponghat STP	E	P	-	10	10
Phaphamau STP	F	P	-	-	10
Mawaiya STP	G	P	-	-	45
Total			60	249	340

STP	District	Status	Process	Effluent discharge	Disinfection
Naini STP	A	E/A	ASP	Irrigation and Ganga River	Add chlorination
Numaya Dahi STP	B	P	WSP	Irrigation and Yamuna River	Maturation ponds
Salori STP	C	S/A	FAB	Ganga River	Chlorination
Rajapur STP	D	P	UASB++	Ganga River	Chlorination
Kodara STP	E	P	UASB++	Ganga River	Chlorination
Ponghat STP	E	P	WSP	Irrigation and Ganga River	Maturation ponds
Phaphamau STP	F	P	WSP	Ganga River	Maturation ponds
Mawaiya STP	G	P	UASB++	Ganga River	Chlorination

E: Existing, A: Augment, S: Sanctioned

1.3 RECOMMENDATIONS

Major sewerage interventions are necessary to reduce river pollution and improve sanitation to all the population and to cope with its future growth. The following recommendations are identified in this report:

1) *Rehabilitate main trunk sewers District A* : This intervention is required to reduce the amounts of wastewater that overflow to surface drains and to reduce the risk of a catastrophic failure. In addition to cleaning and repair of the system it will be necessary to survey the whole system and to store record drawings and data in a readily accessible form (preferably GIS based) to facilitate maintenance and future planning.

2) *Rehabilitate existing pumping stations*: pumping equipment is getting old and is poorly maintained. Pumps and diesel generators should be updated, and operation should be automated. The installed capacity at Gaughat, Alopibagh, and Lukerganj pump stations should be increased to improve standby capacity and prevent overflows during peak flow periods. Significant institutional capacity building and reorganization will be required to ensure sustainable operation and maintenance of the pump stations with emphasis on continuous and reliable operation of diesel generators during power interruptions.

3) *Increase the amount of wastewater conveyed to Naini treatment plant*: The existing treatment plant at Naini is at present not fully utilized and has provision for expansion to 80 mld. This intervention is required to reduce pollutant loads to Ganga and Yamuna rivers and maximize the existing investment. This intervention includes: rehabilitation of Gaughat pump station and rising mains to Naini STP.

4) *Provide new trunk sewer facilities and treatment plants to serve large population centres:* This intervention is required to improve sanitary conditions in densely populated areas and reduce pollutant loads. Several districts are experiencing rapid development and population growth. New water supply projects are being implemented and the amount of wastewater will increase significantly. Present sewage treatment capacity is insufficient to meet the projected sewage load therefore new treatment plants are required.

5) *Implement regulations, collection and treatment systems for on-site sanitation*: Peripheral areas where population densities are less than 120 persons per hectare should be provided with proper on-site sanitation systems. This intervention is also required to improve sanitary conditions and reduce the amount of pathogens in the environment.

Reducing the pollutant loads to water resources and improving the living environment for residents of Allahabad are important issues that can only be addressed by appropriate sanitation and sewerage interventions. These long-term goals can be met by 2030 if sufficient resources are allocated to the construction of sewage treatment plants and wastewater collection systems.

As shown in Figure 1.1, there is at present a large gap between existing treatment capacity and wastewater load. Therefore there is an urgent need to augment treatment capacity and trunk sewers.

These urgent projects should be carried out as Stage I, within 5 to 10 years of adopting the Sewerage Master Plan i.e. 2010 to 2015.

After 2015, the emphasis will be on providing branch sewers and connecting households to the collection system in order to increase the amount of wastewater diverted to the treatment plants. As shown in Figure 1.2, the largest component of the cost during Stage I is for trunk sewers. At Stage II the largest cost component becomes branch sewers. Treatment plants are a relatively small part of the overall cost. The total estimated direct costs including contingency and land acquisition are as follows:

(Crores)

Item	Stage I	Stage II	Total
Direct Cost	241.1	333.1	574.2
Physical Contingency (20%)	48.2	66.6	114.8
Land Acquisition	50.7	11.3	62.0
Total	340.0	411.0	751.0

Direct cost does not include house connection cost

1.4 SELECTION OF PRIORITY PROJECTS FOR FEASIBILITY STUDY

A list of all infrastructure projects identified in the Master Plan is shown in Table 1.2. Priority projects are defined as projects that should be implemented as soon as possible (before 2015) to achieve pollution reduction targets. These projects include diversion of all drains that have been identified as a source of pollution by UPJN. Priority projects are included in the scope of the Feasibility Study.

Projects that have already been sanctioned by UPJN are not identified as priority projects because it is assumed they will be fully implemented in the near future.

The cost breakdown of projects identified for implementation during Stage I is listed in order of priority in Table 1.3.

Table 1.2 Identification of Priority Projects

District	Priority
(1) District A	
Projects	
▪ Augmentation of Naini STP from 60 to 80 mld	A
▪ Rehabilitation of Gaughat MPS and Chachar nala SPS	A
▪ Rehabilitation of existing trunk sewers and installation of new trunk sewers	A
Rational	
▪ District A includes the old city. It is densely populated and discharges the largest amount of raw sewage to the rivers.	
▪ Further increase in sewage is expected as the population increases.	
▪ Sewer network has been well developed in this District.	
▪ Most of sewage in this area has been collected and conveyed to Gaughat MPS but flow in excess of capacity at Naini STP is discharged to Yamuna river.	
▪ Early reduction of 20 mld sewage discharged to the river is achieved by augmentation of Naini STP.	

(2) District B

Projects

▪ Rehabilitation of Lukerganj SPS	A
▪ Construction of Ghaghar nala SPS	A
▪ Construction of Numaya Dahi STP	A
▪ Installation of new trunk sewers	A
▪ Installation of rising main to STP	A

Rational
- Catchment area of Lukerganj SPS is also densely populated and sewage from this area drains into District A.
- The sewage flow in this area should be separated from District A to reduce the load on Gaughat MPS and Naini STP.

(3) District C

Projects

▪ Construction of Salori STP (Sanctioned)	-
▪ Construction of interceptor and SPS (Sanctioned)	-
▪ Installation of new trunk sewers along Salori nala	B

Rational
- The population density of catchment area of Salori STP is not so high.
- Salori nala is within a close proximate of Sangam confluence and raw sewage discharged into the Ganga river affects the bathing people.
- Salori STP is already sanctioned
- UPJN expects to install a trunk sewer along Salori nala.

(4) District D

(D1- Catchment of Alopibagh PS and developed area)

Projects

▪ Construction of Rajapur STP, tapping facility	A
▪ Rehabilitation of Alopibagh PS	A
▪ Upgrading pumping stations, Morigate, Mumfordganj, Allahpur, Daraganj	A
▪ Rehabilitation/replacement of existing trunk sewers and installation of new trunk sewers and rising mains	

Rational
- District D1 is densely populated area and sewage flows into District A.
- The sewage flow in this area should be separated from District A to reduce the load of Naini STP.

(5) District D **(D2 - Low land area near Rajapur nala and less developed area)** **Projects** ▪ Construction of Rajapur nala tapping facility and SPS ▪ Installation of new trunk sewers **Rational** ▪ The population density is lower than that of the catchment area of Alopibagh SPS and the sewage amount is also small. The priority of installation of truck sewers is low.	 A B

(6) District E **Projects** ▪ Construction of Kodara STP and tapping facility ▪ Construction of Ponghat STP and tapping facility **Rational** ▪ Nalas in this district contribute significant pollutant load to Ganga river ▪ This area is developing quickly.	 A A

(7) District F **Projects** ▪ Construction of Phaphamau STP ▪ Installation of new trunk sewers **Rational** ▪ At present small population and low population densities ▪ Future growth area	 B B

(8) District G **Project list** ▪ Construction of Mawaiya STP ▪ Installation of new trunk sewers **Rational** ▪ Low population densities ▪ Discharging downstream of Sangam confluence	 B B

A: Priority works selected for Feasibility Study, to be implemented before 2015

B: Works to be implemented after 2015

Table 1.3 Stage I Project - Implementation Cost

(Million Rs.)

Project	Estimated Cost	+Physical Contingency	Cumulative Cost
1. District A Augment Naini STP and rehabilitation of existing facilities			
(a) Augmentation of Naini STP from 60 to 80 mld	54.0	64.8	
(b) Rehabilitation of Chachar Nala SPS	4.6	5.5	
(c) Rehabilitation of Trunk Sewers and Installing trunk sewer	332.3	398.8	
(d) Branch Sewer	76.3	91.6	
Sub Total	467.2	560.7	560.7
2. District B Divert excess wastewater from Distict A and intercept Ghaghar Nala			
(a) Reconstructin of Lukerganj SPS	57.9	69.5	
(b) Installation of Trunk Sewer	88.2	105.8	
(c) Installation of Rising Main	138.3	165.9	
(d) Construction of Numaya Dahi STP	80.0	96.0	
(e) Land Acquisition of Numaya Dahi STP	275.2	275.2	
(f) Construction of Ghaghar Nala SPS	159.8	191.8	
(g) Land Acquisition of Ghaghar Nala SPS	4.0	4.0	
(h) Branch Sewer	93.6	112.3	
Sub Total	896.9	1,020.5	1,581.2
3. District D Divert excess wastewater from Distict A and intercept Morigate Nala and Rajapur Nala			
(a) Construction of Rajapur STP	625.0	750.0	
(b) Land Acquisition of Rajapur STP	136.0	136.0	
(c) Reconstruction of Morigate SPS	54.8	65.8	
(d) Installation of Rising Main from Morigate Nala SPS	18.4	22.1	
(e) Installation of Rising Main from Alopibagh SPS	34.5	41.4	
(f) Increase capacity of sump	3.3	4.0	
(g) Reconstruction of Mumforganj SPS	198.2	237.8	
(h) Installation of Rising Main from Mumfordganj SPS	27.6	33.1	
(i) Rehabilitation of Trunk Sewers and Installing Trunk Sewer	252.4	302.8	
(j) Branch Sewer	51.2	61.4	
Sub Total	1,401.4	1,654.4	3,235.6
4. District E Intercept Kodara Nala and Ponghat Nala			
(a) Construction of Kodara STP	45.0	54.0	
(b) Land Acquisition of Kodara STP	42.0	42.0	
(c) Construction of Ponghat STP	16.0	19.2	
(d) Land Acquisition of Ponghat STP	50.0	50.0	
Sub Total	153.0	165.2	3,400.8
Total	2,918.6	3,400.8	3,400.8

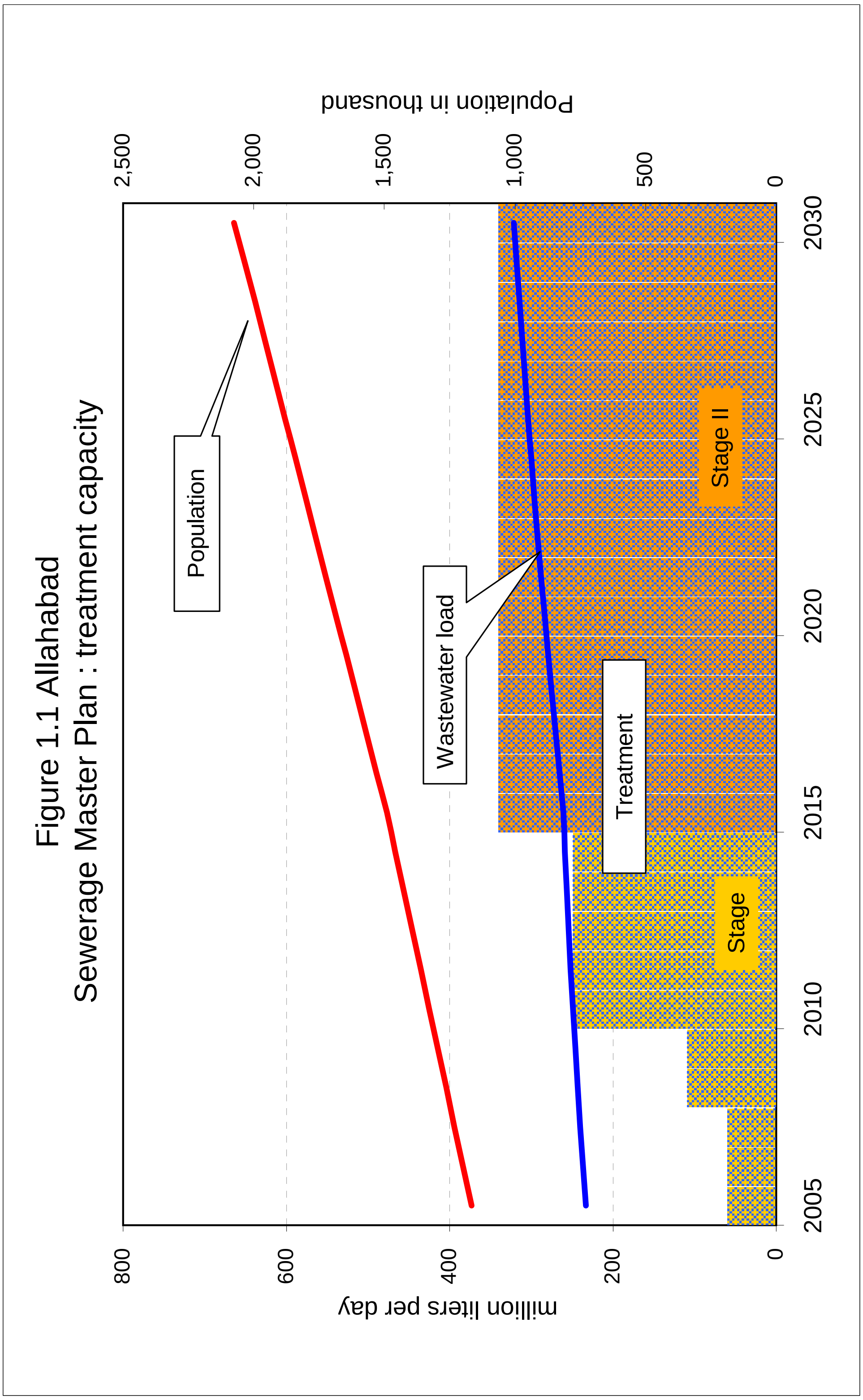
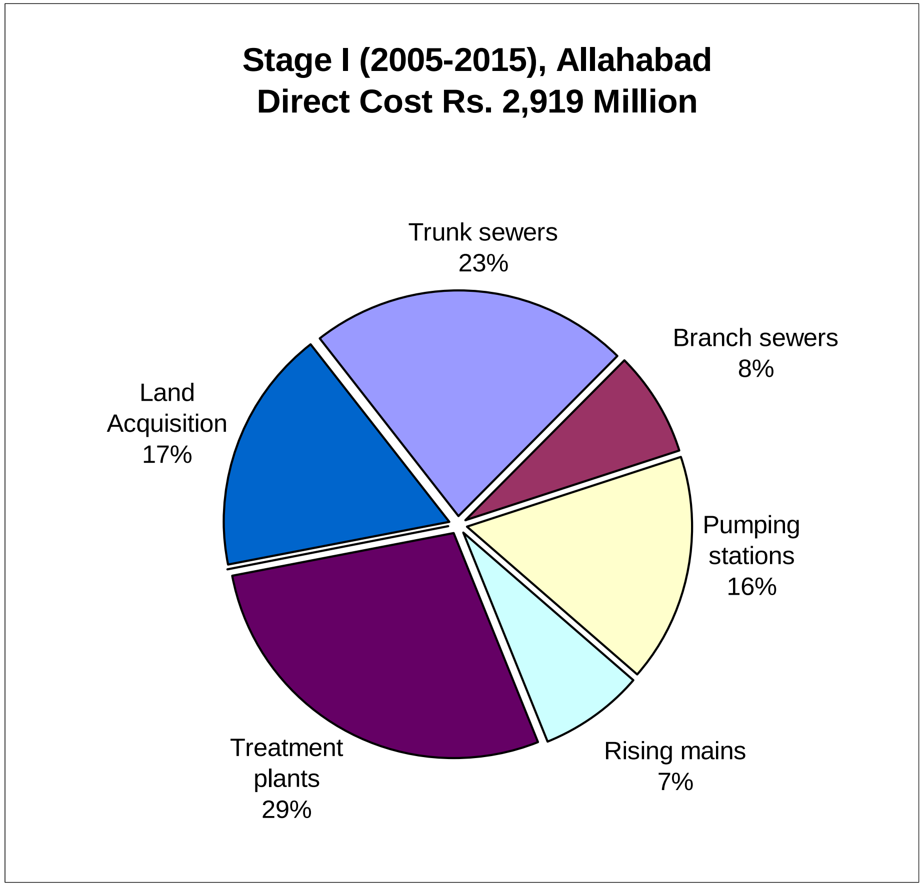


Figure 1.1 Allahabad
Sewerage Master Plan : treatment capacity



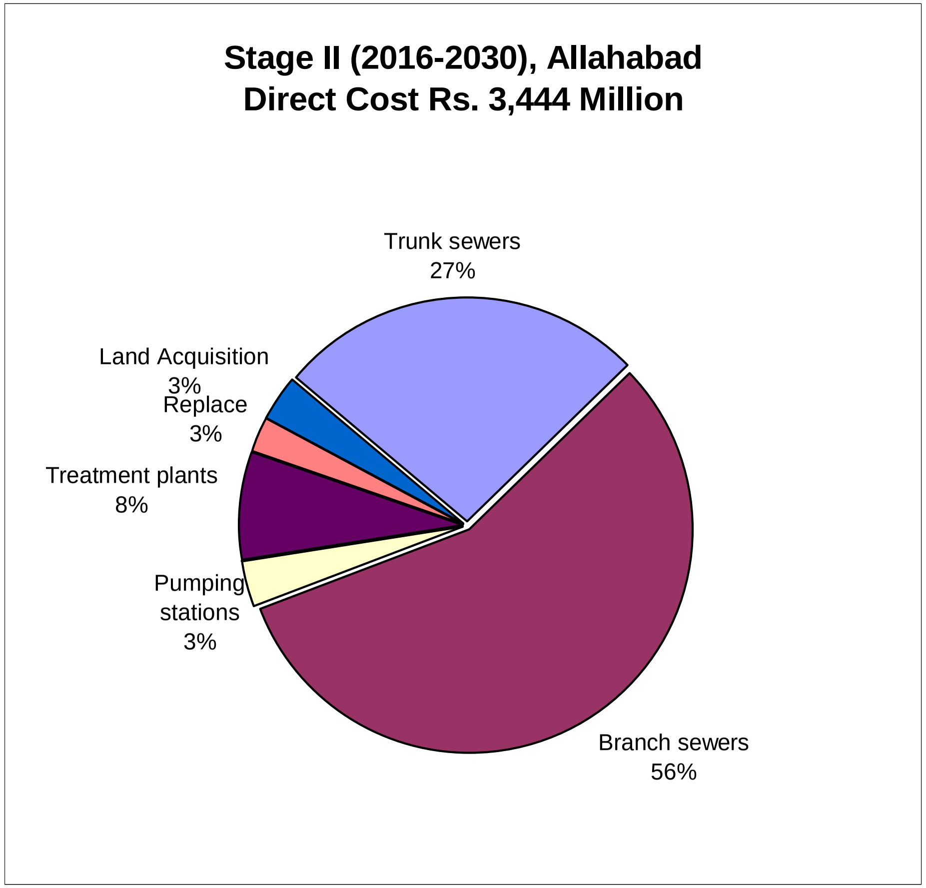


Figure 1.2 Estimated Cost of Sewerage, Breakdown of Direct Construction Cost

CHAPTER 2

INTRODUCTION

CHAPTER 2 INTRODUCTION

2.1 PRESENT WASTEWATER SYSTEMS

The City of Allahabad's wastewater collection and treatment facilities include a collection system and one wastewater treatment plant at Naini with 60 mld capacity. The collection system covers about 45% of the city area and most of this is within the old, densely populated centre core. The total amount of wastewater measured in drains and at the STPs in 2000 was about 210 mld of which 90 mld was diverted into the sewer collection system.

Households that are not connected to sewers discharge sullage (wastewater from kitchen/bathing and grey water from septic tanks) directly to street drains that ultimately discharge to the rivers. Sanitary wastewater (from toilets) is discharged to soak pits or septic tanks where solids are retained and partially reduced in volume.

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.

2.2 REVIEW OF EXISTING INFORMATION

The following background information regarding the city of Allahabad's wastewater collection and treatment capabilities were provided to the JICA Study Team:

- Influent and effluent wastewater characteristics for Naini treatment plant
- UPJN revised Project Feasibility Report (PFR) 2001-2002 for GAP-II proposals
- UPJN Detailed Project Report (DPR) 2002 for 29 mld sewage treatment plant at Salori nala based on fluidized aerobic bio-reactor technology
- UPJN Briefing note for "On site Treatment of Ghaghar Nala" at Karelabagh during Mahakumbh Mela-2001
- Zonal population, water demand and availability of water as per UPJN Pre-Feasibility Report dated March 1996
- Preliminary Estimate for Second Water Works and Improvement of Water Supply System in Allahabad City March 1996 (UPJN)
- Nagal Nigam Water Supply Master Plan for Allahabad City 1995
- Census Data 2001 for wards administered by Allahabad Municipal Corporation
- Nagar Nigam Sewerage Master Plan for Allahabad City 1995
- Long section drawings of existing trunk sewers presented as drawing Nos. 8740/ES/LS-01 to 10 in previous Master Plan.

2.2.1 Previous Studies and Proposals

The proposals identified in the previous sewerage master plan prepared in 1995 are shown in Drawing C1 Appendix C. The previous master plan proposals have not been implemented. The main difficulty has been in crossing the Yamuna river to reach Naini STP. The second difficulty was that the site that was identified by the master plan for the second 80 mld STP at Naini has been given (sold) by Nagar Nigam to the G.O.I. for development of a science park.

Permission to put a new rising main to Naini STP across the new Yamuna Bridge not allowed by the Ministry of Surface Transport, Govt. of India vide its letter RW/WH/12016/105 95/N/U.P. dated 13/3/96 (Appendix A1). The Ministry has stated that the installation of rising mains and water mains has in the past caused considerable damage to bridge superstructures and a policy decision had been taken not to allow such installations on the new bridge. The matter was again referred by the

Additional Secretary & Project Director NRCD to the Secretary (SFT) vide D.O. No. J-140, 15/1/93-GPD dated 12/03/99 but was turned down by the Ministry of Surface Transport vide D.O. letter no. NH/12016/105 95 N-U.P. dated 9/04/99 (Appendix A2).

As an alternate plan UPJN considered moving sewage across the Ganga to an STP at Jhunsi. Permission to use the railway bridge was disallowed by Northern Eastern Railway, Gorakhpur.

Given the constraints UPJN has developed proposals for distributed sewage treatment facilities located at the tail end of various large nalas (Drawing C2.1 & C2.2 – Appendix C). Most of the treatment plants are located in areas where land availability is limited therefore fluidized aerated bio-reactors have been proposed because they require the least amount of space. UPJN has also proposed augmenting capacity at Naini STP from 60 mld to 80 mld to match pumping and rising main capacity at Gaughat MPS. The existing treatment plant was designed with provision for augmentation and space is available within the existing campus.

2.2.2 Infrastructure Management Issues

A comprehensive proposal is required for providing adequate sewerage systems to improve sanitary conditions and reduce the impact on water quality of receiving streams. Key issues identified in previous studies that must be addressed by the Master Plan include:

1) On-site systems:

Pour flush toilets discharging to leach pits or septic tanks are the most popular on-site sanitation facility. In the core area, space limitation constrains the installation of on-site sanitation system and construction of a private toilet within the household. Leach pits require periodic emptying, which is done manually in an unhygienic manner. There is no centralized service for cleaning of on-site systems. Septic tanks and leach pits overflow and discharge to street side drains, which contributes to the pathogen load in the environment.

2) Discharge of sullage:

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

3) Inadequate sewerage coverage and low connection ratios:

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

4) Ingress of storm water and solid waste into sewer system:

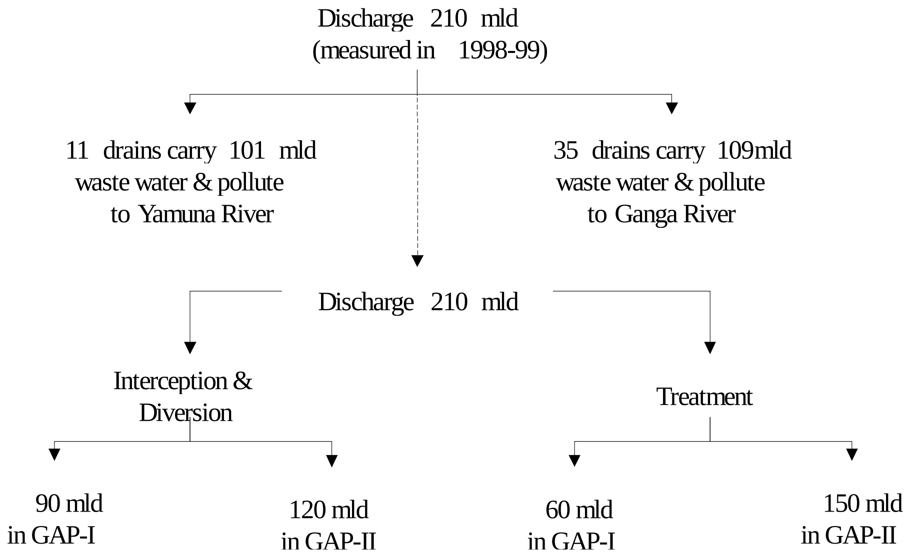
Damaged manholes, sewer defects particularly around the nalas and connections of nalas to the sewerage system have led to the increased risk of solid waste entering and blocking the system. There is currently no way of controlling the amount of storm water that enters the system at locations where drains have been diverted. Storm water overloads the sewer system and causes overflows to the rivers. Augmentation of trunk sewers and treatment capacities to deal with storm water runoff is too costly. Therefore a solution is required for storm water by-pass.

2.3 SUMMARY OF GANGA ACTION PLAN

In response to growing concern over water quality and environmental degradation UPJN planned a phased pollution abatement program. The Ganga Action Plan Phase I (GAP-I) was launched in June, 1986 to reduce the amount of untreated wastewater reaching the Ganga and Yamuna rivers. Schemes completed by Jal Nigam under GAP-I are summarized as follows:

- Renovation of Gaughat pumping station
- Renovation of Intermediate pumping stations
- Relieving sewer in Kydganj area.
- Daraganj sewer and pumping station
- Relieving sewer in Daraganj area
- Tapping of Mumfordganj nala
- Taping of Chachar nala
- Partial taping of Ghaghar nala
- 60 mld sewage treatment works at Naini

In GAP-I only about 30% of wastewater flows could be intercepted and treated. Hence pollution levels in the Ganga and Yamuna rivers remain high.



Source: flows measured by UPJN

Figure 2.1 Flows Intercepted under GAP-I

GAP-II is aimed at intercepting and diverting the remaining flows along Ganga and Yamuna rivers. The following works have been proposed by UPJN for GAP-II:
Sanctioned projects:

- Tapping Salori nala and pumping station
- 29 mld Salori STP with land acquisition for future 101 mld

Projects not yet sanctioned (but identified in PFR)

- Augment capacity of Naini STP by 20 mld
- New 24 mld STP and tapping of drains: Rajapur, Sadar Bazar, TV Tower, Rasulabad
- Interception and diversion of Ghaghar nala
- New 48 mld STP for Ghaghar nala
- New pumping station at Alopibagh and rising main to Salori STP
- New pumping station at Mela area and rising main to Alopibagh SPS

- Interception, diversion and treatment of drains in Jhunsi area
- Interception, diversion and treatment of drains in Mawaiya area
- Interception, diversion and treatment of drains in Sulem Sarai area
- Interception, diversion and treatment of drains in Shivkuti area
- Interception, diversion and treatment of drains in Phaphamau area
- Improvement of sewerage system

The proposals contained in previous studies and DPR provide useful information for this master planning effort. Projects implemented under GAP-I have not provided the intended improvements in water quality because there are still many large drains that have not been diverted. The weakest links in the existing scheme are the pumping stations. At present sewage overflows occur at these stations during daily power failures lasting up to 8 hours. Although emergency power generators are provided, the operating authority (UPJN) has insufficient funds for the purchase of diesel fuel. Furthermore, some of the nala tapping stations have insufficient capacity to deal with dry weather flows which have increased beyond the quantities predicted.

Under GAP-II, UPJN has proposed several new diversion and treatment works to reduce the amounts of sewage flowing to the Yamuna and Ganga. It is noted, however, that the proposals do not provide a comprehensive plan for the development of a sewerage system that is needed to prevent increased flow in nalas and further degradation of the environment. Most notable is the absence of timeframes for the development of new facilities and budgets for maintenance, rehabilitation or replacement of existing facilities.

CHAPTER 3

CITY PLANNING AND POPULATION PROJECTIONS

CHAPTER 3 CITY PLANNING AND POPULATION PROJECTIONS

3.1 UNDERSTANDING PAST AND EXISTING POPULATION

The focus of this section of the study is to document from available information the existing population in Allahabad, understand their spatial distribution, and then develop population growth and distribution scenarios.

The city of Allahabad has a unique character among the cities being studied as a result of its location at the confluence of the Yamuna and Ganga rivers. The confluence is known as Sangam and is a very important religious site. The famous Kumbh Mela takes place every twelve years and attracts millions of pilgrims.

In this project study the detailed analysis of Allahabad has been focussed on the municipal extents and the areas under the Master Plan document. The peripheral growth areas outside of the municipal extents have also been examined and considered for the future growth and expansion of the city. Areas adjacent to the existing municipal extents have been defined in our study as the peri-urban areas. Collectively, these areas are the focus of the population projections and distribution study. Most of the efforts of this study are concentrated on these areas, examining intra-area growth patterns and trends using satellite imagery, field observations, and inputs of local agencies.

The base data used for this study was (provisional census) data obtained from the Census of India, with detailed urban area population and municipal wards for 2001. This data provided the numeric basis for benchmarking the actual population and its decadal growth for the past decade. This information was complemented with past decadal growth rates and population data for earlier decades from the Master Plan documents.

Based on the 2001 census records, the population of the Allahabad urban area was 1,081,622 persons. For the same period, the 70 wards that encompass the municipal area had a population of 990,298 persons.

Table 3.1 Decadal Population and Growth Rate of Allahabad Urban Area

Year	Allahabad Urban Area Population	Urban Area Growth Rates
1951	332,295	
1961	430,730	29.62%
1971	513,036	19.11%
1981	650,070	26.71%
1991	844,546	29.92%
2001*	1,200,000	42.08%
2001**	1,081,622	28.07%

** Estimated by 2021 Master Plan ** From 2001 census data*

3.2 UNDERSTANDING DISTRIBUTION OF EXISTING POPULATION

As described in the methodology under the City Planning and Population Projections report, the project team developed an understanding of the existing population distribution across the urban areas of Allahabad. Comparing this population distribution with a visual interpretation of the satellite imagery helped in a better characterization of the urban development pattern into patches of varying population density levels. This approach helped in assessment of the urban development character of the city in the face of limitations of time and resources under this project.

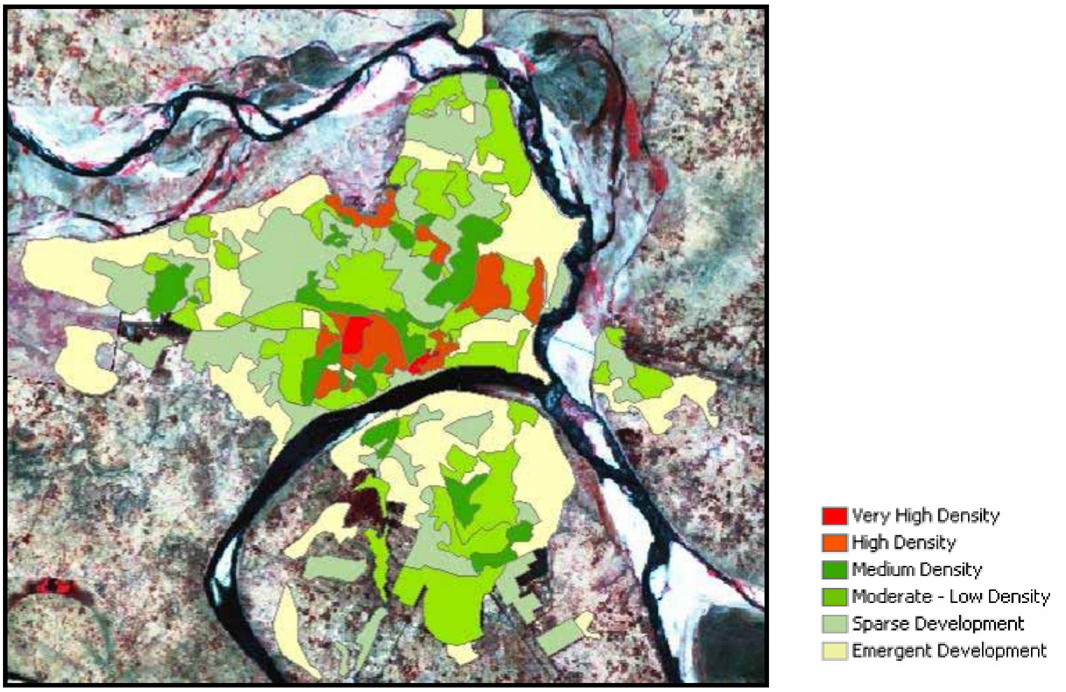


Figure 3.1 Satellite Imagery Interpretation for Development Density

3.3 POPULATION GROWTH PROJECTIONS

The basis of developing the population projections for this study has been the information collected from the Census Department, Lucknow, information provided by Allahabad Nagar Nigam, and from data made available in the master plan documents through the Development Authority.

To establish the growth rates, available data on past decadal growth rates was analysed. During the period from 1951 to 1991, the growth rate ranged between 19% and 29% per decade. Allowing for a dramatic increase in Allahabad's population for the year 2001, a growth rate for the decadal interval 1991 – 2001 was established at 42.08% in the Master Plan. Even examining the trends for the decades from 1951 to 1991, the growth rate established for 2001 seems to be un-realistically high,adjusting the projected population for 2001 with the census population for the same time period.

Forecasting a dramatic increase the period of 1981 to 1991 saw a decadal growth rate of 66%. This aberrantly high growth for 1981 - 1991 is attributed in part to the changed urban extent and the inclusion of surrounding land areas into the Allahabad City census limit.

Based on the master-plan report, different statistical methods were used to project the population growth. These are shown in the table below. It has further been elaborated in the master plan that the average growth projections have been adopted for the document. This population, inclusive of an estimated 60,000 persons for the cantonment area, projects the 2021 population as 40,00,000 persons.

Table 3.2 Master Plan Projections

Item	2001	2011	2021
Geometric	1,310,943	1,705,733	2,219,502
Arithmetic	1,250,305	1,493,029	1,735,753
Parabolic	1,323,771	1,713,127	2,175,949
Average	1,294,973	1,637,296	2,043,735

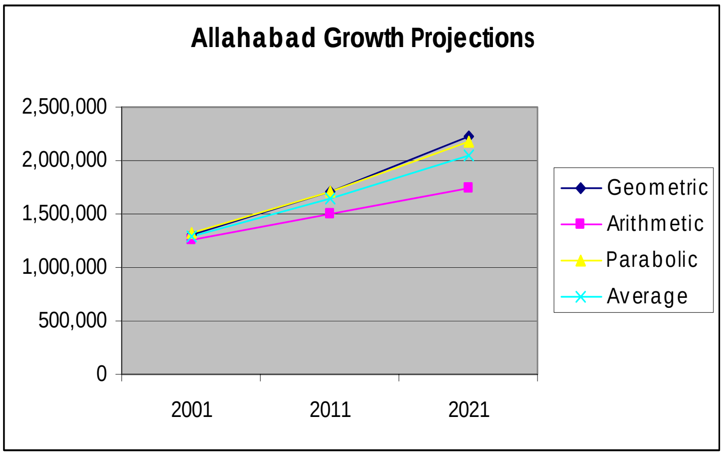


Figure 3.2 Master Plan Projections

Table 3.3 Study Growth Projections

Item	2001	2011	2021	2031
Rate of Growth (Master Plan)	28.52%	26.43%	24.82%	22.89%*
Rate of Growth (Adapted to 2001 Census)	28.07%	26.43%	24.82%	22.89%
Population Projections adjusted to 2001 Census as base	1,081,622	1,367,495	1,706,907	2,097,618

* Projected value using previous decades rate of growth

Focusing on the project area of the municipal extent of Allahabad, including Phaphamau and Naini, the population estimates have been developed and extrapolated only for these areas. These estimates differ from those of the master plan as they exclude Jhunsi from the population projection estimates as well as the growth rates being used have been rationalized for the 1991 – 2001 decadal interval based on the available census data.

With the target year of the Study established as 2030, the Study Team required intermediate stages of population projections for the year 2015 that would coincide with the stages of activity defined in the Sewerage Master Plan development. To correlate population with existing conditions on the ground, it was further required that the final analysis should include estimates for the year 2003. Using the 2001 population as the base, and applying growth rates based on ward characteristics, the final ward-wise populations were generated. The detailed Table with ward wise population estimates for 2003 and forecasts for 2015 and 2030 has been included in the end of this chapter.

In the Table below comparison is presented by forecasting and extrapolating the population for the study target year of 2030 by using the census data, developing growth rates from the master plan (with 2001 census revisions) and using growth rates developed by the Study Team. The resultant population forecast generated by the Study Team, for the municipal extent, Naini and Phaphamau, is overall higher than that would be projected by the master plan for the same time interval.

Table 3.4 Population Projections

Item	BASE (2001)	2003	2015	2030
Estimated Population based on Census Growth Rates	1,081,622	1,136,235	1,526,944	2,209,363
Estimated Population based on Master Plan Growth Rates	1,081,622	1,135,271	1,517,899	2,182,340
JICA Study Projections* (including municipal extents, Naini, and Phaphamau)	1,081,622	1,151,213	1,576,702	2,215,544

* The final population figures used in the study are based on detailed ward-wise analysis and are projected for the target year 2030. The final figures are given in the Table appended at the end of this chapter. These final figures are higher than the figures initially projected.

It is a logical progression then to expect the exercise of population forecast to be complemented with a spatial distribution of the population and a forecast of the increased extent of urbanization which will encompass the forecasted population. This has been addressed in the section on Population Distribution Projections.

3.4 POPULATION DISTRIBUTION PROJECTIONS

3.4.1 Defining Urban Character of Muncipal Wards and Peri-Urban Areas

The urban development areas of Allahabad are fragmented by the interspersing of multiple cantonment areas. Bound on three sides by the Ganga and the Yamuna, its growth spills across the rivers by virtue of the transport connectivity of the bridges to the Phaphamau area to the north, Jhunsi to the east, and Naini to the south. Continuous growth westwards are limited by the presence of the cantonment. However new housing colonies and infrastructure are beginning to draw more people in this direction.

Despite the intent of the master plan and its projections for rapid growth of Allahabad city, most of the growth of Allahabad is currently directed outside of the municipal limits to Phaphamau on the north and Naini on the south. The rapid development of new facilities on the south, an additional road bridge moving traffic across the Yamuna river, and employment potential by the industrial developments make Naini a prime focus of additional growth.

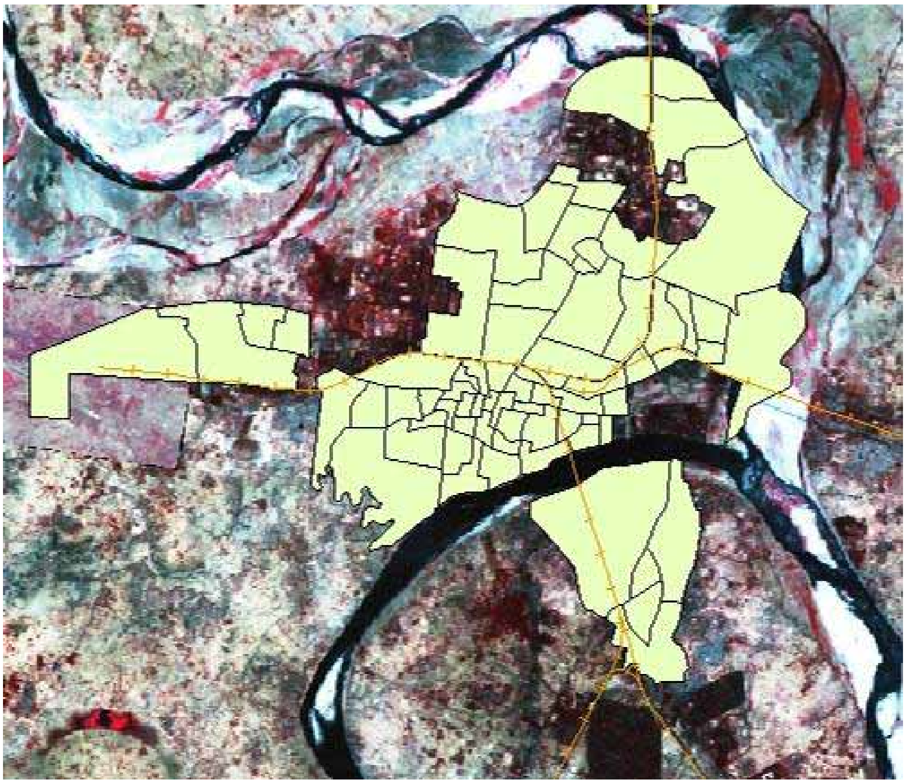


Figure 3.3 Municipal Extent of Allahabad

3.4.2 Defining Growth Characteristics

For the purposes of assigning growth rates by municipal wards, the following growth characteristics were defined and growth rates allocated by ward. Based on an analysis of the growth characteristics of each ward, depending on its current density, road network, master-plan designation, and adjacent ward characteristics, the individual ward growth rates were redefined. Although the table below represents the average growth rate for each decadal interval for the categories defined below, the actual ward-wise growth rates are significantly divergent due to the complex character of the urban development potential within the municipal limits of Allahabad.

As can be seen, the areas designated as “Growth” and “Far” both attract high rates of population increase. The patterns are likely to remain more favourable to the areas designated as “Growth” areas (including Naini and Phaphamau areas) with other wards being more dependent on intra-urban changes to infrastructure.

Table 3.5 Growth Characteristics Defined

Category	Description	Decadal Growth Rate		
		2001 - 2011	2011 - 2021	2021 - 2031
Growth	Growth Areas	55%	35%	30%
Far	Outer Area, far from Core	55%	55%	30%
Proximal	Proximal to Core	40%	25%	15%
Core	Core Area	2.5%	2.5%	2.5%
Average	Background Average Growth Rate	25%	22%	20%

* Outliers to these growth rates exist and are a result of localized characteristics which in instances have a lower or higher growth rate than that for the defined ward characteristics.

3.4.3 Influence on Development Characteristics

The dense development of the city is concentrated between the Yamuna river and the railroad network. Slicing through this and creating an almost north-south road axis, the Kamla Nehru – Jung Bahadur road forms an urban artery. On both sides of it, moving from the dense development in the southern side of the city, the character opens up to a more spacious, semi-formal, administrative and institutional section of the city. As the artery moves north however it transcends into medium density development before being arrested at the cantonment. Fringing the entire northern side of the city, above the cantonment, development is packed in up to the riverfront again. This alternating pattern of dense development opening up and re-metamorphosing into dense development gives the urban fabric of Allahabad its character of interspersed land uses.

Examining growth westwards, again the continuity of the city growth is intersected by another extensive cantonment area that is precluded from urbanization under normal city planning and growth projections. Planned housing developments such as the Transport Nagar and the Railway Colony have sought to act as catalysts to growth in this direction. The presence of the Bamrauli aerodrome and the aerodrome housing colony have also helped attracting development westward. However the critical mass and momentum appears lacking for the want of additional infrastructure and road network to help growing the development potential of this area.

The road network leading out of Allahabad haves expanded the reach of urbanization. Along the Allahabad – Varanasi road, development activity is growing very rapidly. This strip-development will continue to grow and expand in this direction in the future. Along the Allahabad- Janghai road and the Allahabad – Unchahar road commercial and residential activities are growing beyond already developed areas, indicating the action of road network as catalyst for growth, as well as the lack of urban growth control by the urban Development Authorities. On the Allahabad – Kanpur road/ Allahabad- Kaushambi road the growth rates are higher and more extensive. The commercial and industrial activities are growing rapidly as well is the development of residential colonies. The approach to development planning seems to be more along the lines of letting the master-plan follow the development, formalizing and accepting it rather than controlling it. This disturbing trend lies at the heart of being unable to manage the development character of Allahabad and plan for future infrastructure development in a systematic and cohesive manner.

Major catalysts for development across the river appear to be the quality of the transportation network bridging the river, as well as the availability of land without the development restriction introduced by the cantonments in the main city area. The development of the Science City and other large institutional developments on the south form major attractions to the growth in Naini. The master plan also envisages more development in this area as compared to other trans-river areas due to its growing critical mass, infrastructure, and land availability.

With these patterns, unless there is a major re-arrangement of land-holding pattern, it appears that the growth of Allahabad will continue to move outward, across the rivers, confined predominantly by the availability of road network. Also, as has been evidenced from the 2001 census data, the growth rate of the city has been in the same range as in earlier decades of around 28% decadal growth, not as per that expected by the master plan at 42%. This reflects a ground reality that any catalytic actions anticipated in past decade have yet to mature adequately to translate into accelerated growth rates. This in combination with the national trends of some slowdown in the urban growth of large cities, the growth rates projected by the Study Team are more conservative and in line with the preceding decadal trends.

3.4.4 Data Constraints and Limitations

The ward maps for Allahabad were acquired after significant effort. The boundaries of these remained relatively unclear at the edges. Some adaptations were made to better fit the satellite imagery base map.

The changing course of the Ganga river made the mapping and analysis of the river-side extent more complex. Whereas the river course at the north-eastern edge was much farther away (as depicted in city and municipal maps), the current satellite imagery provides a very different picture. It is suggested that the Nagar Nigam consider mapping the wards in the context of this updated imagery and the road network to more accurately define ward-wise distribution/ density of population.

The limited time on this project did not allow for detailed ground truthing and assessment of the actual development density across the entire city. Consequently the input of local agencies was essential in validating the existing conditions. The support of the officials of the Nagar Nigam is acknowledged in this regard.

3.4.5 Population Projections by Ward

The Table below gives the finalized ward-wise population figures and the overall summary of population for each of the years of consideration under this study.

Table 3.6 Population Projection by Ward (Page 1 of 2)

Ward ID	Ward Name	Population 2003	Population 2015	Population 2030	Population Density 2003	Population Density 2015	Population Density 2030
1	Mundera	31,066	56,658	120,085	64.7	118.0	250.1
2	Malakraj	13,842	19,242	23,969	281.5	391.3	487.5
3	Govindpur	24,600	35,264	55,314	159.7	228.9	359.0
4	Harwara	30,117	44,448	65,053	96.2	142.0	207.9
5	Rajakbarpur	35,460	55,051	68,575	257.9	400.5	498.8
6	Nihalpur	8,193	8,440	8,758	351.6	362.2	375.9
7	Dariyabad	5,868	6,044	6,272	290.5	299.2	310.5
8	Krishna Nagar	11,234	13,051	14,439	393.3	457.0	505.6
9	Momfordganj	19,946	23,588	29,089	239.2	282.9	348.9
10	Jahangirabad	12,978	21,959	39,906	22.6	38.2	69.5
11	Tagore Town	15,173	23,367	38,708	119.9	184.7	305.9
12	Karelabagh	20,319	34,380	66,344	52.8	89.3	172.3
13	Railway Kshetra	17,657	26,059	40,875	67.8	100.1	157.0
14	Vaghambari Gaddi	9,770	12,770	17,847	139.2	181.9	254.3
15	Sulem Sarai	14,814	23,718	34,713	230.3	368.7	539.6
16	Civil Kshetra (1)	9,401	13,874	21,762	65.8	97.1	152.3
17	Civil Kshetra (2)	10,171	15,011	23,545	75.8	111.9	175.5
18	Rajapur	30,492	46,960	77,789	119.7	184.3	305.3
19	Meerapur	17,318	23,683	29,962	249.4	341.1	431.5
20	Katghar	11,022	15,564	21,465	212.5	300.1	413.9
21	Elanganj	22,556	36,113	52,854	180.2	288.6	422.3
22	Phaphamau	29,628	51,313	78,392	114.5	198.5	303.1
23	Pura Padain	11,794	13,449	13,973	438.0	499.4	518.9
24	Dariyabad (2)	20,155	24,226	26,803	328.8	395.2	437.2
25	Naini	19,518	27,131	33,796	232.7	323.5	403.0
26	Pura Manohar Das	6,431	6,624	6,874	298.6	307.5	319.1
27	Myorabad	20,462	29,332	41,382	187.4	268.7	379.0
28	Salori	41,131	46,114	53,202	221.7	248.5	286.7
29	Madhwapur	11,066	11,398	11,828	292.4	301.1	312.5
30	Umarpeer Niwan	20,861	28,998	39,064	293.9	408.5	550.3
31	Karaili	19,689	27,369	38,249	183.0	254.4	355.5
32	Chakamtai	12,871	21,778	35,873	114.8	194.3	320.0
33	Chakdondi	8,059	12,710	17,530	192.2	303.1	418.1
34	Teliyarganj	36,056	57,726	87,523	167.7	268.5	407.1
35	Chak Raghunath	9,558	13,701	21,491	174.2	249.7	391.7
36	Shahrarabagh	5,629	5,798	6,017	247.9	255.3	265.0
37	Mohalsimganj	7,717	7,949	8,249	496.6	511.5	530.8
38	Darbhanga	18,775	27,708	43,462	84.6	124.8	195.8
39	Rambagh	6,883	9,568	13,371	174.7	242.8	339.4
40	Maithiganj	23,198	23,896	24,798	411.2	423.6	439.6
41	Azad Square	10,807	15,950	25,018	80.2	118.3	185.6
42	Malviya Nagar	19,117	19,692	20,435	552.0	568.6	590.1
43	Daraganj	19,834	24,631	27,252	341.8	424.5	469.6
44	Khuldabad	5,594	5,762	5,979	255.6	263.2	273.1
45	Vakhtipari	9,133	9,590	9,821	682.1	716.2	733.5
46	Nai Basti	8,353	8,604	8,929	299.1	308.1	319.7
47	Alopibagh	7,310	7,530	7,814	259.4	267.2	277.3
48	Tulsipur	19,327	23,231	25,702	370.3	445.1	492.5
49	Beniganj	14,492	21,330	29,809	229.4	337.6	471.8
50	Saralgarh	10,071	10,373	10,623	398.7	410.6	420.6
51	Bahadurganj	10,008	10,309	10,557	676.2	696.6	713.3
52	Pura Dhaku	11,447	15,189	19,966	329.0	436.6	573.9
53	Sultanpur Bhawa	9,896	10,113	10,189	623.6	637.2	642.0
54	Lukarganj	12,041	18,285	31,926	93.4	141.8	247.6
55	Atarsuiya	7,236	7,453	7,734	413.0	425.4	441.4
56	Badshahi Mandi	12,760	13,144	13,640	501.8	516.9	536.4
57	Chaukhandi	8,991	9,442	9,669	557.1	585.0	599.1
58	Khalasi Line	7,769	8,159	8,355	825.6	867.1	887.9
59	Ranimandi	11,021	11,264	11,348	1002.8	1024.9	1032.6
60	Naya Katra	10,327	15,683	25,677	110.0	167.1	273.5
61	Katra	8,418	11,318	13,958	265.9	357.5	440.9
62	Bhardwajpuram	29,127	30,003	31,136	318.2	327.7	340.1
63	Himmatganj	13,220	18,377	23,825	247.9	344.7	446.8
64	Shahganj	8,759	9,023	9,363	273.6	281.9	292.5
65	Pura Dalel	7,196	7,413	7,693	159.3	164.1	170.3
66	Atala	13,613	14,022	14,360	569.6	586.7	600.8
67	Daira Shah Azmal	7,432	7,595	7,652	670.2	684.9	690.0
68	Dodipur	7,093	7,306	7,582	514.7	530.2	550.2
69	Baksi Bazar	9,354	9,579	9,723	580.3	594.2	603.2
70	Meeraganj	8,205	8,452	8,771	416.5	429.0	445.2
TOTAL MUNICIPAL EXTENTS		1,039,429	1,390,854	1,913,707			

Table 3.6 Population Projection by Ward (Page 2 of 2)

Area ID	Area Name	Population 2003	Population 2015	Population 2030	Population Density 2003	Population Density 2015	Population Density 2030
101	Area 1	6,286	10,725	20,109	28.7	49.0	91.9
102	Area 2	3,969	6,563	11,813	44.4	73.4	132.2
103	Area 3	2,268	3,750	7,594	3.6	6.0	12.2
104	Area 4	32,001	54,600	98,280	64.7	110.4	198.7
105	Area 5	5,018	7,763	15,719	6.1	9.4	19.1
106	Area 6	4,499	7,200	12,420	17.6	28.2	48.6
107	Area 7	13,099	20,337	25,332	177.9	276.2	344.0
108	Area 8	15,016	23,597	32,178	35.0	55.0	75.0
TOTAL PERI-URBAN AREA		82,156	134,535	223,445			
OVERALL TOTALS		1,121,585	1,525,389	2,137,152			

CHAPTER 4

WATER SUPPLY SYSTEMS

CHAPTER 4 WATER SUPPLY SYSTEMS

4.1 MUNICIPAL WATER SUPPLY

Jal Sansthan is responsible for providing safe and potable drinking water. Municipal piped water supply dates back to 1892.

The main source of raw water for the municipal piped water supply system is the Yamuna river. Intake of water from the river in 2003 was about 80 mld (approximately 35% of the total water supplied). Water is taken from a number of intake wells along the banks of the Yamuna at Karelibagh Raw Water Pumping Station. Raw water is pumped to Khushrobagh Water Works where it is treated using chemical and physical clarification followed by rapid sand filtration. Present treatment capacity is 130 mld.

In 2003, approximately 137 mld was extracted from 134 deep tube wells operated by Jal Sansthan. In addition to tube wells operated by Jal Sansthan, there are many privately owned and institutional tube wells that provide an unknown amount of water. A total of 2438 hand pumps provide water in places of water scarcity.

Table 4.1 Total Municipal Water Production

Municipal Supply	Production capacity (mld)
Yamuna River	80**
Tube wells	137**
Total	217

** Production figures reported by Jal Sansthan
Estimated by JICA study team

4.2 QUANTITY OF WATER SUPPLIED AND CONSUMED

Allahabad city is divided into 11 zones for the distribution of water as shown in Figure 4.1. Three of these are supplied exclusively from the Khushrobagh Water Works and six exclusively from ground water. A zoning pattern based exclusively on the source of raw water is not feasible as the large central area of the city is covered by a network that is fed by both surface water and ground water.

At present, the population of Allahabad is 1,049,800 residents (including a daily floating population). Estimated water production from municipal supplies is 217 mld.

Table 4.2 Estimated Per Capita Water Consumption

Population served	1,049,800 (in 2003)
Production capacity per capita	207 lpcd
Less leakage losses estimated at 15%	180 lpcd

Including institutional/commercial components but excluding private supplies.

The above production capacity appears to be a reasonably good estimate of the average amount consumed. Based on estimates from UPJN, private supplies could account for an additional 20%. Therefore present per capita consumption is probably closer to 210 lpcd.

4.3 WATER SUPPLY PROBLEMS THAT AFFECT THE DEVELOPMENT OF SEWERAGE

The following water supply deficiencies have been identified in the water supply master plan and by UPJN:

4.3.1 Severe Power Supply Situation

The prevailing power situation in the city is quite severe with frequent power failures for prolonged periods. Vital components like raw water pumping, equipments in Treatment Works, clear water pumping, tube well pumps in the water supply system are dependent exclusively on power supply for their operation. Poor power situation hence leads to severe dislocation and damage to the system operation as well as operational schedule.

For supply of water to consumers, the intended schedule by the Authority is an intermittent supply spread over a daily period of 10 hours in three shifts, 6 A.M. to 10 A.M., 12.00 A.M. to 2.00 P.M. and 6.00 P.M. to 10.00 P.M. This schedule with adequate level of supply can hardly be met due to various operational constraints. Residents at lower elevations receive water for a longer period while those at higher locations have shorter duration of supply.

4.3.2 Unaccounted for Water

Large quantity of water is lost through the system due to leakages in pipeline and appurtenances as well as due to unaccounted for water consumption. A pilot study conducted in a small area, of the city during the previous master plan identified about 40% of water is lost in the system. The component of UFW associated with leakage is estimated at approximately 15%.

4.3.3 Deficiency in System Provision

A number of components in the system as discussed in the water supply master plan have inadequate capacity. Major components are raw water pumping mains, clear water reservoirs in Khushroobagh Water Works, zonal overhead tanks and pipelines at various places. Such deficient system provisions lead to poor level of supply to consumers.

Although 217mld of water is distributed to the public, the level of services is not up to the norm, because of topography of the town and improper distribution network. Water scarcity has become a regular feature in certain areas especially in summers, because of old network of pipelines. Most of these have completed their designed life and need replacement.

The following localities have been identified by UPJN as water deficient:

Table 4.3 Water Deficient Localities

No.	Name of Locality	1991 census Ward No.
1	Part of Beniganj	4
2	Saidpur near Shastri Nagar	6
3	Koocha Gangadas, Part of Malviyanagar, Khusal Parwat, Chak Gangadas	13
4	Part of Bahadurganj and Mutthiganj	14
5	Gujarathi Mohalla	15
6	Atarsuiya	16
7	Unchamandi	17
8	Northern part of Civil lines	23
9	Balarampur House	25
10	Allahpur, Alopibagh, Baghambari Housing Scheme	33
11	Sohbatiabagh	34
12	Bairahna Madhwapur	35
13	Krishnanagar and Netanagar	
14	Colonel ganj	
15	Naini	

4.4 MASTER PLAN FOR IMPROVED WATER SUPPLY

The implementation of additional treatment capacity and strengthening of the distribution is essential to support the development of sewerage system.

In 1995, Nagar Nigam prepared a master plan for improvement of water supply. The plan proposed a per capita water supply of 225 lpcd. In the meantime new guidelines have been issued directing planners to use 150 lpcd. In 1996 UP Jal Nigam proposed a plan to improve distribution and augment capacity of the municipal water supply. This plan has only been partially implemented apparently for lack of funding.

UPJN is still trying to get funding to improve the water distribution system. The following improvement projects with a total cost of Rs 1562.8 lakh have been identified as urgent priorities:

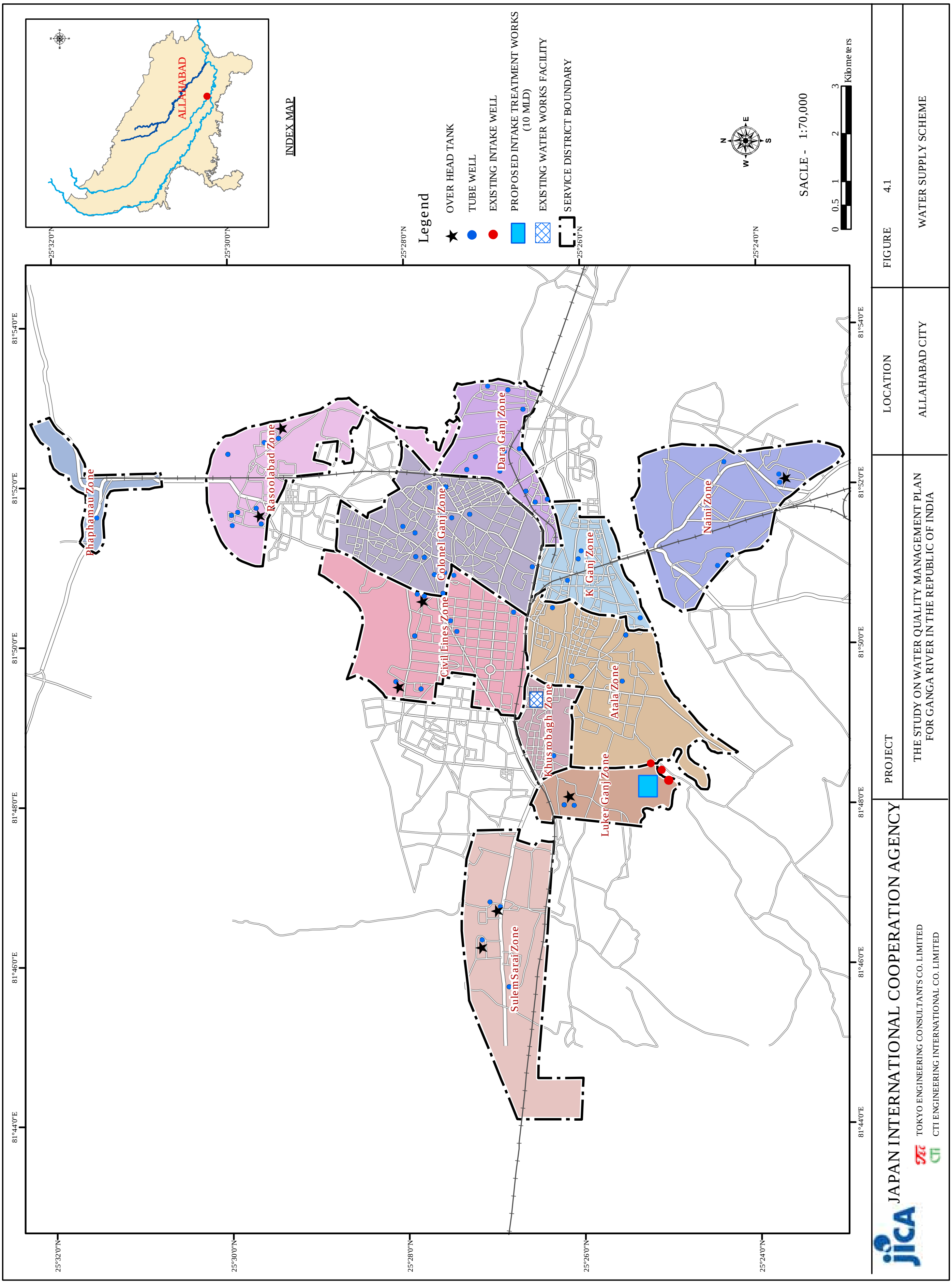
- Karelibagh Intake
  - Construction of a new water works
  - Improvement of exisiting intake well
- Khusrobagh water works:
  - Rehabilitation of feeder mains,
  - New pump house,
  - Rehabilitate clariflocculators,
  - Rehabilitate alum dosing plant
- Khushrobagh distribution zone:
  - New booster station
  - Reinforcement of distribution piping
- Civil lines distribution zone: Reinforcement of distribution piping
- Colonel ganj zone : Reinforcement of distribution piping
- Rasoolabad zone: Reinforcement of distribution piping

In addition to these improvements UPJN has identified the requirement for new tube wells and storage capacity to meet the projected water demand to 2030. The projections for water demand provided by UPJN are given in Tables 4.4 for reference. Zone wise domestic water demand is calculated using 150 lpcd. Institutional water demand is added to domestic demand and varies from 20 to 23% of the total demand depending on the number of institutions, schools and hospitals located in the zone. UPJN has not added any provision for UFW to their projections which in accordance with planning guidelines should be an additional 15%. UPJN demand estimates are summarized as follows:

Table 4.4 Water Demand Estimates: UPJN Allahabad

Year	Population	Demand (mld)	Planned per capita production (lpcd)	Planned per capita consumption (lpcd)	Production deficit (mld)
	(1)	(2)	(3) = (2)/(1)	(4) = (3)/1.15	(5)
2015	1,510,200	290	192	167	47
	1,366,943				
2030	2,085,400	402	193	168	123
	1,932,857				

(1) UPJN population projections for zone 1 to 11, excluding cantonment
(2) demand at 150 lpcd domestic plus institutional/commercial; excluding fire fighting requirements
(4) assumes 15% lost to leakage
(5) assumes no improvement in existing production facilities


INDEX MAP
ALLAHABAD
Legend
OVER HEAD TANK
TUBE WELL
EXISTING INTAKE WELL
PROPOSED INTAKE TREATMENT WORKS (10 MLD)
EXISTING WATER WORKS FACILITY
SERVICE DISTRICT BOUNDARY
SACLE - 1:70,000
0 0.5 1 2 3 Kilometers
Bhaphamau Zone
Rasoolabad Zone
Dara Ganj Zone
Colonel Ganj Zone
Civil Lines Zone
K Ganj Zone
Naini Zone
Atala Zone
Khusrobagh Zone
Luker Ganj Zone
Sulem Sarai Zone
FIGURE 4.1
LOCATION ALLAHABAD CITY
PROJECT THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA
WATER SUPPLY SCHEME
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO ENGINEERING CONSULTANTS CO. LIMITED
CTI ENGINEERING INTERNATIONAL CO. LIMITED

CHAPTER 5

SEWERAGE PLANNING FRAMEWORK

CHAPTER 5 SEWERAGE PLANNING FRAMEWORK

This section identifies the criteria used for planning sewerage improvements as well as evaluating sewerage development strategies.

5.1 PLANNING HORIZON

The planning horizon for the sewerage master plan is 2030 with phased implementation of sewerage projects occurring in 5-year intervals. The first stage will consist of priority projects that should be completed within one to five years following the adoption of the Master Plan.

The capacity of civil works is sized for the projected requirements in the year 2030. The capacity of mechanical and electrical systems is planned for the year 2015 with provision for future expansion by adding or changing pumps in subsequent phases as flows increase.

Land requirements for sewage treatment works are based on the projected capacity required for the year 2030. In the first stage, treatment works would be implemented with capacity for the year 2015 and provision for future expansion to ultimate design capacity.

5.2 PLANNING CAPACITY

The timing for future sewerage infrastructure and the expansion of capacity depends on actual population growth and wastewater flows. “Planning capacity” refers to maintaining the infrastructure capacity above projected loadings. In general planning capacity serves three purposes:

1) It allows the system to remain effective over the period required to implement capital improvement projects (typically 2 to 5 years). Coupled with projected demands, planning capacity gives the City a mechanism to initiate master planning updates and staged improvements over the planning horizon. This allows the city to stay ahead of system needs.
2) Planning capacity can allow the system to accommodate unplanned growth over short time periods without unduly overtaxing the system, thereby allowing the city to plan or adjust infrastructure upgrade schedules to accommodate the growth.
3) Planning capacity is necessary to address flow variations. Wastewater flow can vary considerably from projected flows depending on actual population growth trends, connection rates and changes in per capita water consumption. Flows can also vary considerably over the short term. In Allahabad seasonal variations are associated with infiltration and inflow due to rainfall and groundwater during the monsoon season. The floating population (visitors, and workers) magnifies diurnal flow variation.

Based on engineering experience the JICA Study Team has included planning capacity when sizing main trunk facilities and treatment plants by assuming a 100% connection ratio.

Future capital improvements such as expansion of treatment plants or augmentation of capacity at pumping stations should be triggered at 10% of the design capacity during the growth phase in each sewerage service district. As the district approaches the phase where it has maximized growth within its boundaries, and it’s population has stabilized (for example central district), wastewater needs will be driven primarily by maintenance of the existing system. During this phase 5% represents a reasonable target for triggering capital improvements.

5.3 LEVEL OF SERVICE

Reducing the pollutant loads to water resources and improving the living environment for residents of Allahabad are important issues that must be addressed by appropriate sanitation and sewerage interventions. These long-term goals can only be met if the existing sewerage infrastructure is fully utilized and extended to serve all densely populated urban areas.

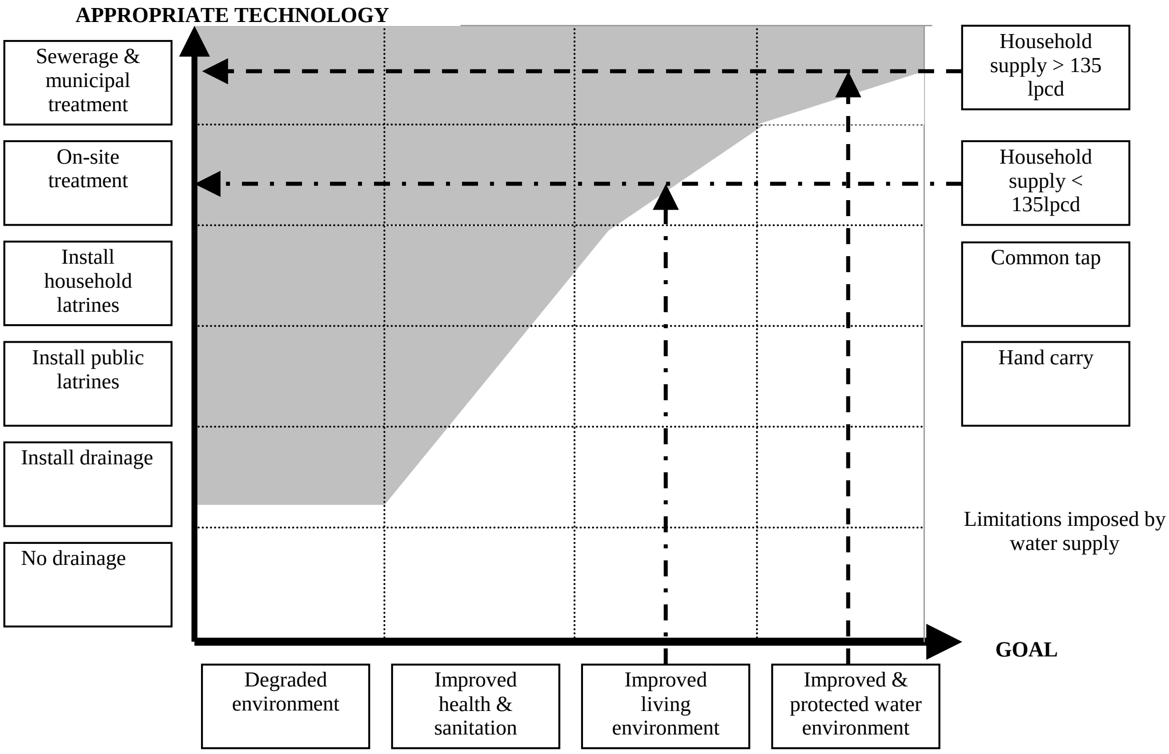


Figure 5.1 Goal and Level of Service Matrix

Sewerage is an appropriate method of meeting pollution control goals when two criteria are met:

1) As shown in Figure 5.1, the technology used to achieve a given goal depends on the level of water supply. The goal of protecting the water environment can only be met by providing conventional sewerage and only if water supply is sufficient to produce self-cleansing velocities. As prescribed by Indian Standard Code IS 1172 and National Building Code a minimum per capita water supply of 135 lpcd is required to sustain conventional sewerage.

2) Another limiting factor is population density. Current practice and experience in other developing countries indicates that conventional sewerage is seldom cost effective in urban areas where the population density is less than 120 persons per hectare.

Wherever these two criteria cannot be met, properly constructed on-site treatment systems should be used and upgraded over time as population density increases or to complement improvements in water supply services.

A summary of the goals, levels of service and stepwise implementation approach proposed for each district/area is presented in Table 5.1:

Table 5.1 Step-wise Progression to Sewerage Development in Allahabad

Goal	District A, D	District B, C	District E, F	District G	FSA-1, FSA-2
Protecting water environment	Sewerage and off-site treatment	Sewerage and off-site treatment	Sewerage and off-site treatment ↑	Sewerage and off-site treatment ↑	Future sewerage and off-site treatment ↑
Improving living environment	↑	↑	On-site treatment for low population densities	On-site treatment for low population densities	On-site treatment
Improved health and sanitation	↑	↑	↑	↑	↑
Present situation	40% sewerage coverage high population densities	0% - 30% sewerage coverage high population densities	No sewerage Growth areas	20% sewerage coverage Growth areas	No sewerage, low population densities future growth potential

5.4 SEWERAGE DEVELOPMENT STRATEGY

Development of sewerage will, wherever possible, be integrated with existing GAP infrastructure in order to reduce the overall investment cost.

1) Existing infrastructure should, where economically feasible, be rehabilitated before investing in new works. This approach will in most cases be more cost effective and result in more immediate benefits such as improved treatment levels.

2) Eventually sewerage should be provided in all urban areas where densities exceed 120 persons per hectare and water supply is sufficiently developed to support water borne sewerage (i.e. > 135 lpcd).
   - Households with water connections should be obligated to connect to sewer systems if they are located in areas that are already sewered.
   - Households that have adequate water supply connections but are located in areas where trunk sewers will likely not be provided for some time should be required to improve their sanitation by upgrading their existing cesspits or septic tanks. In later years they should be connected to the extended sewer network.
   - Households that do not have adequate water supply should, for the immediate future, be served by pour flush toilets with new cesspits or septic tanks. The choice between cesspits or septic tanks depends on whether enough land is available for the more efficient and cost effective septic tanks.

3) Peripheral areas where population densities are 120 persons per hectare or less should be provided with proper on-site sanitation systems. This intervention is also required to improve sanitary conditions and reduce the amount of pathogens in the environment. Systems for collecting and treating septage are required.

4) Development of new housing colonies in peripheral areas requires special measures to ensure they are line in with urban master plans, water supply and sewerage master plans. It may not be possible or cost effective to extend trunk sewers into these colonies until several years later. It is proposed that in new developments, sewerage systems including small-scale treatment works should be built ahead of trunk sewer facilities

with the cost borne by the developer in accordance with user-pay principal. As the overall sewerage master plan is implemented the small-scale decentralized treatment facilities in various colonies can be shut down in a planned order once the trunk collector sewers and centralized treatment facilities are completed.

5) Institutional reform and capacity building will be required to ensure that operating authorities have the ability and equipment to properly manage and finance the operation and maintenance of sewerage schemes. Otherwise continued development will not be sustainable.

6) Whether planned or not, it is often the case that people will be living illegally on publicly owned land, land used by railroads, along nalas or similar areas. Although it is undesirable, people are living there, and usually they cannot easily be relocated. Most of these people are living in extremely bad sanitary conditions and their needs for improved sanitation cannot be ignored. It is difficult to move ahead with sewerage in these areas because people do not have land ownership rights or cannot afford such services. The same holds true in economically disadvantaged communities where people cannot afford the connection and service charges for sewerage. Therefore, realistic measured are required to ensure a proper level of sanitation is attained in these areas. Non-sewerage schemes and low cost sanitation improvements are discussed in a separate report.

7) The implementation and monitoring of on-site treatment facilities in urban centers must be formalized to make them more effective. Formalizing on-site treatment will require:

a. Setting standards for construction of pit latrines, septic tanks and soak away pits
b. Regulating construction by issuing permits and follow-up inspections
c. Regulating maintenance intervals of septic tanks and cesspits through mandatory collection
d. Providing equipment and facilities for collection and disposal of septage
e. Regulating municipal and/or private sludge collection services through licensing and manifest system to ensure proper disposal

5.5 SEWER SERVICE AREAS AND POPULATIONS

Future population projections are an integral component of planning for future wastewater infrastructure. These projections have been developed by JICA Study Team with reference to 2001 census data and the city's land use master plan for 2030. Using computerized GIS tools, the projected populations for each ward is allocated to each sewage district in proportion to the area falling within each district.

5.5.1 Existing Sewerage Districts

The previous sewerage master plan had evaluated a number of options. The recommended option divided the Municipal Corporation of Allahabad into five sewerage districts namely:

1. Gaughat
2. Alopibagh
3. Naini
4. Sulem Sarai
5. Katra, Teliarganj (right bank) and Phaphamau (left bank)

This zoning pattern and treatment facilities proposed by the previous master plan are presented in Drawing C1. Zonal boundaries were fixed primarily on the basis of topographical features, development patterns and land use. Of the above districts, Gaughat, Alopibagh, Katra and Naini districts are covered to various extents by the integrated sewerage system. Small townships set up in Sulem Sarai and Taliarganj Districts have small network covering their territory only.

The previously defined districts must be reconfigured to deal with the following new constraints and developments that have occurred since the master plan was completed:

- Crossing the bridges to Phaphamau, and Naini is not allowed
- Naini STP cannot be expanded to more than 80mld
- Gaughat pumping station has a maximum capacity of 80 mld because existing rising mains across the railway bridge cannot be augmented.
- Salori STP, 29 mld is under construction by UPJN

5.5.2 Proposed Sewerage Districts

A number of alternative district layouts have been evaluated and a recommended plan is presented in Section 7 of the Master Plan. The proposed sewer service areas and sewerage districts for 2030 are presented in Figure 7.2.

The Sewerage Master Plan is developed for areas within the greater limits of the Municipal Corporation (as defined by the Development Authority) that have or will have population densities greater than 120 persons per hectare. Approximate population densities based on a visual interpretation of land use are derived from satellite images.

Potential service areas lying outside the present municipal administrative boundary have been designated as future service areas (FSA). Areas that do not meet required densities within the planning horizon of 2030 are identified as non-sewerage areas (NSA). These areas have the potential of contributing significant wastewater loads to the Yamuna and Ganga rivers and as such will require proper on-site sanitation and treatment systems to reduce the amount of wastewater discharged to surface drains. In the longer term beyond 2030, on site treatment systems in designated non-service areas can be converted to sewerage as population density increases.

5.5.3 Future Sewer Service Areas

Future Service Areas outside the current Municipal Corporation limit are described as follows:

- FSA1 is south of the Naini District G, just outside the current Municipal Corporation limit. Wastewater generated in this area tends to flow east towards Ganga via Mawaiya nala. Population projections indicate that density in this area will be greater than 120 person per hectare by the year 2015, therefore this area is designated as a future service area to be included with District G.
- FSA2 is a small pocket just west of <u>District B</u> outside the current Municipal Corporation limit, and separated from District E by the railway line to the north. Wastewater in this area tends to flow south to the Yamuna river via Sasur Khaderi river and Ghaghar nala. Visual interpretation of land use indicates that density in this area is already greater than 120 persons per hectare therefore this area is designated as a future service area to be included in District B.

5.5.4 Non-Sewerage Areas

Non-Sewerage areas are identified as follows:

- NSA1 is Jhunsi district, a growth area outside the current Municipal Corporation limits to the the east of Allahabad across the Ganga river (refer to Chapter 7, Figure 7.5). Development has occurred along both sides of the main road along the East-West axis. There are no sewers in this area. Most wastewater is discharged to soak pits and septic tanks. Sullage finds its way into natural drains that discharge downstream of the Sangam.

  The area is sparsely populated but growing quickly and new land areas are being developed to south and to the east. This area is outside the sewerage master plan study area. However

NRCD Steering Committee and local UPJN have indicated that natural drains are becoming new sources of pollution that will need to be intercepted and treated in near future.

Projected populations indicate that densities will remain below 120 persons per hectare for the planning horizon. Therefore this area is designated as a non-sewerage area because it will generally not be cost effective to provide collection system infrastructure. Therefore households in this area should be required to have properly installed on-site systems to pre-treat wastewater before discharging to drains.

It is suggested that in future, depending on availability of funds, the larger drain, viz, Shashtri Bridge drain and Lotey Haran nala be diverted to a small treatment plant to the south.

5.5.5 Populations Served

Table 5.2 Populations and Sewer Service Areas

Sewer Service Areas	Service Area (ha)	Population		
		2003	2015	2030
District A	1,321	373,770	432,397	503,469
District B	874	119,996	181,533	262,488
District C	647	113,184	158,714	225,944
District D	1,709	274,812	364,449	502,414
District E	928	96,858	153,819	258,872
District F	186	21,321	36,913	56,394
District G	1,382	101,264	162,602	266,989
Total	7,048	1,101,205	1,490,427	2,076,570

Includes future service areas and daily floating population. Does not include Khumb Mela population.

Non Sewerage Area: Jhunsi

J1 & J2	465	29,122	39,306	50,918
J3	398	13,916	21,867	29,819
J4	700	17,496	24,494	38,490
Total	1,562	60,534	85,667	119,227

5.6 WATER CONSUMPTION PER CAPITA

The quantity of wastewater to be intercepted and treated will depend on the population and on the amount of water consumed. Unfortunately the amount of water consumed per capita is not well documented because there are no water meters and many households have installed private tube wells.

The Manual on Water Supply and Treatment (Ministry of Urban Development, New Delhi, May 1999) recommends the following values for planning municipal water supply systems for domestic and non-domestic purposes:

Table 5.3 Guideline Values for Future Per Capita Water Supply

Sl.	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

Figures exclude unaccounted for water (UFW) which should be limited to 15%
Figures include requirements for water for commercial, institutional and minor industries. However, the bulk supply to such establishments should be assessed separately with proper justification

Based on production figures reported by UPJN the present estimated per capita consumption is approximately 210 lpcd, which is higher than 150 lpcd proposed by Indian guidelines for planning water supply systems. The JICA Study Team recommends using the higher value for planning sewerage in order to provide a more realistic estimate of wastewater volumes for Phase I projects. However, in accordance with planning guidelines, these higher per capita rates are decreased gradually to 150 lpcd by 2030 to reflect the effects of limited water resources.

The following values for domestic water consumption are adopted in the Master Plan.

2003: 210 lpcd + 30% UFW allowance + 22 lpcd (1) C/I = 295 lpcd
2015: 170 lpcd + 20% UFW allowance + 42 lpcd (1) C/I = 254 lpcd
2030: 150 lpcd + 15% UFW allowance + 42 lpcd (1) C/I = 221 lpcd

Note(1): Allowance for commercial/institutional (C/I) and minor industries demand provided by UPJN)

The allowance for UFW is in accordance with Indian planning guidelines. This assumes that some programs for reducing UFW will be implemented. The allowance for commercial and institutional demand is the value calculated by UPJN for water supply system. It is based on known consumers.

5.7 WASTEWATER RETURN FACTOR AND PER CAPITA CONTRIBUTION

Wastewater generated per capita is calculated using the proposed per capita water supply rates:

Table 5.4 Per Capita Wastewater Generation Rates

Item	2003	2015	2030
Per capita water consumption (lpcd)	295	254	221
Return factor	0.70	0.70	0.70
Per capita wastewater discharge (lpcd)	206 say (205)	172 say (175)	155

The wastewater return factors are within the range of 0.7 and 0.8 in accordance with Manual on Sewerage and Sewage Treatment (Ministry of Urban Development, December 1993. As reported in the previous sewerage master plan, there is no allowance for groundwater infiltration because the groundwater table in Allahabad is generally deeper than sewer depths.

The criteria adopted in the Master Plan is cross checked by comparing the total flow measured in drains across the city to the amount of wastewater generated by calculations. The total flow measured in 1999 for areas contributing flow (including cantonment and floating population) was about 210 mld from an estimated population of 1,065,877. This is equivalent to 200 lpcd of wastewater, which is close to the amount calculated.

5.8 PREDICTED WASTEWATER QUANTITY

5.8.1 Total Wastewater Quantity

The population for each sewered and non-sewered area is multiplied by per capita contribution to obtain estimated wastewater flow.

Table 5.5 Projected Total Wastewater Production

(mld)

Sewer Service Areas	2003	2015	2030
District A	76.62	75.67	78.03
District B	24.60	31.77	40.69
District C	23.20	27.77	35.02
District D	56.34	63.78	77.87
District E	19.86	26.92	40.13
District F	4.37	6.46	8.74
District G	20.76	28.46	41.38
Total	225.75	260.83	321.86

Detailed calculations showing sewage generated by ward, by sewerage district and tributary area for the years 2003, 2015 and 2030 are presented in Table 5.6.

5.8.2 Sewer Connection Ratios

The number of households connected to sewers at present is unknown but thought to be relatively high in sewer-covered areas. However, a comparison between the total amount of wastewater produced to total amount measured in open drains indicates that only 10 to 15% of the sewage is actually reaching trunk sewers. This indicates a serious problem at the branch sewer level.

The Master Plan identifies a number of trunk sewers facilities and lateral sewers. However the full benefits of these facilities cannot be realized unless a program to improve coverage of branch sewers and household connections is carried in parallel. Future targets are proposed as a means of identifying the quantities of infrastructure and approximate budget requirements required over the planning horizon.

The ultimate sewer connection ratio of 80% has been selected to meet water quality improvement goals. However, achieving such a target may not be realistic given the large number of projects that have to be implemented in such a short timeframe. Furthermore it is not only a question of providing new infrastructure. There is also a huge backlog of maintenance and repairs to restore existing system.

Table 5.7 Existing and Proposed Sewer Connection Targets

Sewer Service Areas	2003	2010	2015	2030
District A	40%	45%	55%	80%
District B (Zone-B1)	30%	40%	50%	80%
District B (Zone-B2)	0%	0%	0%	50%
District C	0%	0%	0%	80%
District D1 (Pumping Area)	30%	35%	45%	80%
District D2 (Gravity Sewer Area)	0%	0%	0%	80%
District E	0%	0%	0%	50%
District F	0%	0%	0%	50%
District G	20%	20%	20%	80%
FSA 1	0%	0%	0%	50%
FSA 2	0%	0%	0%	80%

Note: the connection of ratio for District E and FSA1 is less than 80% because it is at present less populated and therefore a lower priority. Sewerage will only be implemented after 2015 therefore it is not likely that a higher sewer connection ratio can be achieved.

5.9 WASTEWATER TREATMENT PLANT DESIGN

5.9.1 Wastewater Characteristics

Wastewater composition differs from one situation to the other and is dependant on the level of sanitation, water usage, type of collection system, retention time in sewers and infiltration. Characteristics influence the choice of treatment method, extent of treatment and quantities of solids produced.

Average Biol-chemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) are the two most important factors for sizing treatment plants in the Master Plan. JICA Study Team conducted a sampling programme to determine wastewater characteristics. Various contributing drains were identified for this purpose and the influent wastewater at Naini STP and Gaughat SPS emergency sewer outfall were also measured.

Table 5.8 Summary of Measured Wastewater Characteristics

Parameter		**Nalas (1)**				**Sewers**	
	units	**Salori**	**Ghaghar**	**Chachar**	**Rajapur**	**Emerg. Outfall**	**Naini STP (2)**
BOD	mg/l	72	67	32	37	250	142
COD	mg/l	192	144	69	66	400	
TSS	mg/l	100	648	98	552	648	384
pH		7.4	7.5	7.0	7.1	7.1	
Temp.	^0C	27	28	29	28	28	

Parameter		**Nalas (3)**			
	units	**Salori**	**Ghaghar**	**Chachar**	**Rajpur**
BOD	mg/l	75	144	164	52

Source: (1) JICA Study Team, measurements taken Nov 4 to 6, 2003.
(2) Average monthly reported by UPJN
(3) Analyzed by Moti Lal Nehru Regional Engineering Collage Allahabad

Theoretical wastewater strength is calculated based on the amount of wastewater discharged per capita, BOD loading of 45 grams/person/day and SS loading of 90 grams/person/day.

Parameter	**Unit**	**2003**	**2015**	**2030**
Per capita wastewater	lpcd	205	175	155
BOD	mg/l	220	257	290
TSS	mg/l	439	514	580

The values actually measured at the treatment plant and sewer outfall are much weaker. The dilute wastewater can be easily explained by the very large amount of wastewater from tapped drains. BOD and TSS values during the earlier phases of the project will likely be weaker than those calculated above because a large portion of the flow will be from tapped drains. However, as sewerage coverage and household connection rates are improved the BOD and SS values will increase. Therefore, wastewater strength used for preliminary process calculations and sizing of treatment facilities should be based on a proportional blend using proposed connection ratios. The BOD strength recommended for design of future wastewater facilities has been calculated for each district and presented in Table 5.9.

5.10 ENVIRONMENTAL QUALITY STANDARDS

The degree of treatment depends on the standards specified by the Central Pollution Control Board and adopted by the NRCD.

Table 5.10 Treated Effluent Quality Standards

Parameter	Unit	Discharged to water bodies	Discharged to land for agriculture
Total Suspended Solids	mg/l	50	100
BOD (5 days at 20^{o}C)	mg/l	30	50
COD	mg/l	250	_
Faecal Coliforms*	MPN/100 ml	Desirable < 1000 Max < 10,000	< 10,000
pH Value		5.5-9.0	5.5-9.0
Sulphides	mg/l (as S)	2.0	-
Total Chromium	mg/l (as Cr)	2.0	5.0

* NRCD guidelines August 2002

Irrespective of final mode of disposal, faecal coliform in treated effluent should not exceed 10,000 MPN/100ml. This will require that all treatment plants have some form of disinfection process or tertiary treatment process for reducing fecal coliform counts.

5.11 CHOICE OF TREATMENT TECHNOLOGY

5.11.1 Treatment Options

The performance of several treatment plants implemented under GAP and YAP has been reviewed by the study team with the objective of identifying which processes would be most suitable for future treatment facilities. Findings of the review are reported in Vol-III-11, Supporting Report. "Case Study on Sewage Treatment Plants."

A qualitative comparison of treatment processes is presented in Table 5.11.

The choice of a treatment technology is driven primarily by the availability of land, the ability of the process to meet required effluent criteria and total life cycle cost. If sufficient land can be provided, then the JICA Study Team recommends that Waste Stabilization Ponds be used since these will provide the most reliable treatment at the lowest annual operating cost.

Where land is limited, the following processes should be considered (in order of preference) with the addition of tertiary treatment to reduce faecal coliform:

- Aerated Facultative Ponds (AL) <50 mld
- Upflow Anaerobic Sludge Blanket (UASB) for flows > 50 mld
- Fluidized Aerated Bio-reactor (FAB) for flows up to 70 mld

5.11.2 Post Treatment Options for UASB Technology

The Upflow Anaerobic Sludge Blanket (UASB) treatment process is in general unable to meet the required effluent criteria without the addition of post treatment processes. Typically UASB is suitable for treatment of very high BOD waste from industries as a form of pre-treatment before disposal to municipal wastewater treatment systems. Data from a number of UASB plants indicates that the effluent is highly anoxic because of dissolved gases. Thus the effluent exerts a very high immediate oxygen demand on receiving streams, i.e., same effect as a high BOD load. The BOD, sulphide and sulphate contents in UASB effluent generally exceed NRCD effluent standards for discharge to inland waters even with 1 day polishing ponds as post treatment.

The option of combining UASB with some form of aerobic post treatment has been suggested by the Steering Committee for the present Study. For obtaining better effluent quality, the following post-treatment alternatives may be taken into consideration:

- Trickling filter
- Aerated lagoons

(1) Trickling Filter

In this option high rate trickling filters would be applied instead of an effluent polishing pond. The trickling filters are followed by final sedimentation tanks. Sludge from the sedimentation tanks is sent to drying beds. A trickling filter is a biological filter system, in which wastewater is continuously distributed over a bed of media. The wastewater organic and nitrogen components will give rise to bacterial growth as a bio film onto the fixed media. The bacteria remove BOD, and if sufficiently low loading rates are applied the nitrification (conversion of ammonia to nitrate) will also occur.

Trickling filters may be expected to reduce the BOD and sulphide content of the wastewater appreciably, bringing these parameters well within the standards. They will, however, not be sufficient to bring faecal coliform counts to within the desired standards. Nevertheless, they greatly improve effluent quality.

Assuming a raw wastewater BOD of 300 mg/l, the effluent from a typical 200 mld UASB can be expected to have a BOD of 105 mg/l, representing a loading rate of 21,000 kg/day. A total of 20 trickling filters 36.0 m in diameter would be necessary.

After the trickling filters, final sedimentation should be provided with a surface loading rate of 1 $m^3/m^2/hr$. Three sedimentation tanks with a diameter of 59.5 m would be required.

The total land requirement for 200 mld UASB is roughly 54 hectare. Substituting trickling filters for final polishing ponds would require 42 hectare (54 – 16 for FPU + 4 for TF). The investment cost for trickling filters is relatively high and so are the O&M requirements. Typical energy requirements would be in the range of 100 to 120 kw for pumping and 50 to 60 kw ventilation.

The effluent quality would be much better than required by the standard. However FC levels remain higher than allowable:

TSS	20-30 mg/l
BOD	10-15 mg/l
Sulphides	0 mg/l
Faecal Coliform count	Aprox. 100,000 MPN/100ml

(2) Aerated Lagoons

In this alternative, aerated lagoons would be applied instead of effluent polishing ponds.

An aerated lagoon is a basin in which the wastewater is treated on a flow-through basis. Generally aeration is provided by floating aerator equipment. From the engineering aspect, they should be considered complete-mix reactors without recycle, having a residence time of minimum three days. After the aerated part, an area should be provided for sedimentation of the solids, which can be an unaerated end-part of the lagoon, or final sedimentation tanks, depending on the amount of solids to be settled.

Aerated lagoons require less surface than ponds because depth can be substantially larger (up to 4.0m), but since decay of faecal coliform is related more to HRT than to any other parameter, pond surface still would have to be fairly substantial unless chlorination is used for disinfection.

For a flow of 200 mld the volume required to reduce BOD from 105 mg/l to 30 mg/l would require about a 1.5 day retention period. This is equivalent to 300,000 m^3, with a surface area of 320,000m^2 assuming a 3.5 m depth in the aeration zone and 1.0m in the quiescent zone.

The total land requirement for 200 mld UASB including a 1 day FPU is roughly 54 hectare. Substituting aerated lagoons instead of final polishing ponds would require 70 hectare (54 – 16 for FPU + 32 for AL). Investment costs for aerated lagoons are in the order of Rs 53 million.

The effluent quality can be estimated to be:

TSS	20-30 mg/l
BOD	5-10 mg/l
Sulphides	0 mg/l
Faecal Coliform count	Aprox. 10,000 to 100,000 MPN/100ml

Energy use would be in the range of 400 to 600 kW per hour, mainly determined by the energy used for the aerator equipment which varies depending on the season.

(3) Overall Comparison of Post Treatment Options:

Criteria	**Post Treatment**	
	Trickling filter	**Aerated lagoon**
Land	1	2
Investment cost	2	1
O&M	2	1
Effluent	2	1
Total	7	5

Most favorable=1

The ranking indicates that aerated lagoons provide the most cost-effective post treatment of UASB effluent to enable it to meet the discharge criteria set by NRCD.

5.11.3 Unit Rates Applied in the Calculation of Treatment Costs

Land requirements and cost criteria used for comparison of options in Chapter 6 are as follows:

Table 5.12 Land Requirements and Cost Per mld for Various Treatment Processes

(million Rs., million Rs./year)

Treatment Process		Area Required (ha/mld)	Capital Cost			Annual O&M Cost
			Total	M/E	Civil	
Wastewater Stabilization Pond*	WSP	1.25	1.6	0.03 (2%)	1.57 (98%)	0.06
Aerated Lagoon + Chlorine Disinfection	AL	0.35	2.5	0.50 (20%)	2.00 (80%)	0.30
Aerated Lagoon + Maturation Ponds	AL+	0.75	3.2	0.64 (20%)	2.56 (80%)	0.32
Activated Sludge + Chlorine Disinfection	AS	0.20	2.7	1.08 (40%)	1.62 (60%)	0.36
Activated Sludge + Maturation Ponds	AS+	0.60	3.4	1.36 (40%)	2.04 (60%)	0.38
Fluidized Aerated Bed + Chlorine Disinfection	FAB	0.06	4.6	2.76 (60%)	1.84 (40%)	0.59
UASB with + Post Treatment (AL)	UASB++	0.35	3.0	1.05 (30%)	1.95 (70%)	0.13

Source: JICA Study Team "Evaluation of Sewage Treatment Plants" under GAP and YAP.
* WSP includes maturation ponds and cost of low lift pumps at head works
Capital costs exclude cost of land; O&M costs include energy costs and staffing costs.

WSP includes the use of maturation ponds to reduce faecal coliform counts. Other options assume disinfection using chlorine, which is inexpensive and generally very effective. Other alternative disinfection technologies are still being evaluated at pilot scale plants and have not yet been proven cost effective for large-scale applications. Maturation ponds are added to other treatment processes if the life cycle cost is attractive and sufficient land is available.

5.12 SEWER DESIGN CRITERIA

Criteria used for the evaluation and preliminary sizing of trunk sewers, pumping stations criteria are in accordance with the Manual on Sewerage and Sewage Treatment (Ministry of Urban Development, December 1993) and current practice adopted in Detailed Project Reports.

Sewers

Peak factors	Nalas	2.5
	Trunk sewers	2.5 for Population < 50,000
		2.25 for population 50,000 – 750,000
		2.00 for population > 750,000
Hydraulic design:		
Gravity pipes:	Manning's equation	$V= 1/n\ R^{2/3}\ S^{1/2}$,
	Roughness factor	n= 0.015 old concrete pipe
		n= 0.017 old brick sewer
	Minimum velocity	0.60 m/s initial flow
		0.80 m/s ultimate flow
	Maximum velocity	3.00 m/s
	Maximum depth	d/D= 0.8 at ultimate peak flow
Pressure pipes:	Hazen William's formula	$V= 0.85\ C\ R^{0.63}\ S^{0.54}$
	Roughness factor	C= 100 new cast iron pipe
		C= 80 old cast iron pipe
		C= 110 PSC pipes
	Minimum velocity	0.8 m/s
	Maximum velocity	3.0 m/s

Pumping stations:

Peak factor:		2.0 for large stations
Sump detention time:		
	Vertical turbine pumps:	5 minutes at ultimate peak flow
	Submersible pumps:	3.75 minutes at ultimate peak flow
	Maximum:	30 minutes at average flow
Minimum number of pumps:		
		3 pumps each with capacity for ½ PF
		2 pumps each with capacity for the non-PF
At critical stations:		50% standby capacity at peak hour
		100% standby capacity at non-peak

Table 5.6 District Wise Population and Wastewater Generation

(1) District Wise Population

	Area (ha)	2003			2015			2030		
		Resident	Floating	Total	Resident	Floating	Total	Resident	Floating	Total
District A	1,321	368,007	5,763	373,770	425,188	7,209	432,397	494,279	9,190	503,469
District B (Including FSA)	875	118,866	1,130	119,996	179,749	1,784	181,533	259,794	2,694	262,488
District C	647	113,184	0	113,184	158,714	0	158,714	225,944	0	225,944
District D	1,709	271,311	3,501	274,812	359,533	4,916	364,449	495,161	7,253	502,414
District E	928	96,858	0	96,858	153,819	0	153,819	258,872	0	258,872
District F	186	21,321	0	21,321	36,913	0	36,913	56,394	0	56,394
District G (Including FSA)	1,382	101,264	0	101,264	162,602	0	162,602	266,989	0	266,989
Total	7,048	1,090,811	10,394	1,101,205	1,476,518	13,909	1,490,427	2,057,433	19,137	2,076,570

(2) District Wise Watewater Generation

(mld)

	2003			2015			2030		
	Resident	Floating	Total	Resident	Floating	Total	Resident	Floating	Total
District A	75.44	1.18	76.62	74.41	1.26	75.67	76.61	1.42	78.03
District B (Including FSA)	24.37	0.23	24.60	31.46	0.31	31.77	40.27	0.42	40.69
District C	23.20	0.00	23.20	27.77	0.00	27.77	35.02	0.00	35.02
District D	55.62	0.72	56.34	62.92	0.86	63.78	76.75	1.12	77.87
District E	19.86	0.00	19.86	26.92	0.00	26.92	40.13	0.00	40.13
District F	4.37	0.00	4.37	6.46	0.00	6.46	8.74	0.00	8.74
District G (Including FSA)	20.76	0.00	20.76	28.46	0.00	28.46	41.38	0.00	41.38
Total	223.62	2.13	225.75	258.40	2.43	260.83	318.90	2.96	321.86

(3) Contributing Population by Sewer Sub-Catchment (Page 1 of 2)

District	Sub-Catchment	Resident									Floating			Total		
		Inside of Municipality			Outside of Municipality			Total								
		2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030
District A	A-1	17,747	25,862	40,173	0	0	0	17,747	25,862	40,173	278	438	747	18,025	26,300	40,920
	A-2	7,359	10,828	16,940	0	0	0	7,359	10,828	16,940	115	184	315	7,474	11,012	17,255
	A-3	6,767	8,966	11,905	0	0	0	6,767	8,966	11,905	106	152	221	6,873	9,118	12,126
	A-4	32,653	33,560	34,395	0	0	0	32,653	33,560	34,395	511	569	640	33,164	34,129	35,035
	A-5	51,984	53,540	55,394	0	0	0	51,984	53,540	55,394	814	908	1,030	52,798	54,448	56,424
	A-6	27,012	35,005	42,825	0	0	0	27,012	35,005	42,825	423	593	796	27,435	35,598	43,621
	A-7	7,649	7,878	8,176	0	0	0	7,649	7,878	8,176	120	134	152	7,769	8,012	8,328
	A-8	30,416	31,312	32,371	0	0	0	30,416	31,312	32,371	476	531	602	30,892	31,843	32,973
	A-9	9,704	9,958	10,173	0	0	0	9,704	9,958	10,173	152	169	189	9,856	10,127	10,362
	A-10	62,354	71,789	83,366	0	0	0	62,354	71,789	83,366	977	1,217	1,550	63,331	73,006	84,916
	A-11	20,530	26,364	31,460	0	0	0	20,530	26,364	31,460	322	447	585	20,852	26,811	32,045
	A-12	16,483	17,030	17,590	0	0	0	16,483	17,030	17,590	258	289	327	16,741	17,319	17,917
	A-13	40,754	50,672	60,243	0	0	0	40,754	50,672	60,243	638	859	1,120	41,392	51,531	61,363
	A-14	36,595	42,424	49,268	0	0	0	36,595	42,424	49,268	573	719	916	37,168	43,143	50,184
	Sub Total	368,007	425,188	494,279	0	0	0	368,007	425,188	494,279	5,763	7,209	9,190	373,770	432,397	503,469
District B	B-1	72,155	105,211	144,829	0	0	0	72,155	105,211	144,829	1,130	1,784	2,694	73,285	106,995	147,523
	B-2	33,612	54,201	89,633	0	0	0	33,612	54,201	89,633	0	0	0	33,612	54,201	89,633
	FSA 2	0	0	0	13,099	20,337	25,332	13,099	20,337	25,332	0	0	0	13,099	20,337	25,332
	Sub Total	105,767	159,412	234,462	13,099	20,337	25,332	118,866	179,749	259,794	1,130	1,784	2,694	119,996	181,533	262,488
District C	C-1	22,059	35,316	53,549	0	0	0	22,059	35,316	53,549	0	0	0	22,059	35,316	53,549
	C-2	17,024	27,572	41,937	0	0	0	17,024	27,572	41,937	0	0	0	17,024	27,572	41,937
	C-3	35,318	50,592	76,376	0	0	0	35,318	50,592	76,376	0	0	0	35,318	50,592	76,376
	C-4	17,678	19,819	22,867	0	0	0	17,678	19,819	22,867	0	0	0	17,678	19,819	22,867
	C-5	21,105	25,415	31,215	0	0	0	21,105	25,415	31,215	0	0	0	21,105	25,415	31,215
	Sub Total	113,184	158,714	225,944	0	0	0	113,184	158,714	225,944	0	0	0	113,184	158,714	225,944

(3) Contributing Population by Sewer Sub-Catchment (Page 2 of 2)

District	Sub-Catchment	Resident									Floating			Total		
		Inside of Municipality			Outside of Municipality			Total								
		2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030
District D	D-1	6,983	10,358	16,360	0	0	0	6,983	10,358	16,360	109	176	304	7,092	10,534	16,664
	D-2	11,498	16,103	24,305	0	0	0	11,498	16,103	24,305	180	273	452	11,678	16,376	24,757
	D-3	9,951	15,024	24,271	0	0	0	9,951	15,024	24,271	156	255	451	10,107	15,279	24,722
	D-4	17,540	24,833	34,399	0	0	0	17,540	24,833	34,399	275	421	640	17,814	25,254	35,038
	D-5	5,434	8,021	12,581	0	0	0	5,434	8,021	12,581	85	136	234	5,519	8,157	12,815
	D-6	2,460	3,630	5,696	0	0	0	2,460	3,630	5,696	39	62	106	2,499	3,692	5,802
	D-7	3,927	5,981	9,773	0	0	0	3,927	5,981	9,773	62	101	182	3,989	6,082	9,955
	D-8	12,567	19,754	30,698	0	0	0	12,567	19,754	30,698	197	335	571	12,764	20,089	31,269
	D-9	11,876	17,691	28,097	0	0	0	11,876	17,691	28,097	186	300	523	12,062	17,991	28,620
	D-10	21,177	24,970	31,262	0	0	0	21,177	24,970	31,262	332	423	581	21,509	25,393	31,843
	D-11	24,511	30,050	33,571	0	0	0	24,511	30,050	33,571	384	509	624	24,895	30,559	34,195
	D-12	12,790	15,146	17,349	0	0	0	12,790	15,146	17,349	200	257	323	12,990	15,403	17,672
	D-13	8,907	9,174	9,521	0	0	0	8,907	9,174	9,521	141	154	179	9,048	9,328	9,700
	D-14	36,669	39,447	43,642	0	0	0	36,669	39,447	43,642	574	669	812	37,243	40,116	44,454
	D-15	17,539	24,832	34,398	0	0	0	17,539	24,832	34,398	274	421	639	17,814	25,253	35,038
	D-16	19,591	24,981	33,960	0	0	0	19,591	24,981	33,960	307	424	632	19,898	25,405	34,592
	D-17	47,891	69,538	105,278	0	0	0	47,891	69,538	105,278	0	0	0	47,891	69,538	105,278
	Sub Total	271,311	359,533	495,161	0	0	0	271,311	359,533	495,161	3,501	4,916	7,253	274,812	364,449	502,414
District E	E-1	23,026	41,994	88,970	0	0	0	23,026	41,994	88,970	0	0	0	23,026	41,994	88,970
	E-2	11,554	18,469	31,897	0	0	0	11,554	18,469	31,897	0	0	0	11,554	18,469	31,897
	E-3	15,488	24,238	40,217	0	0	0	15,488	24,238	40,217	0	0	0	15,488	24,238	40,217
	E-4	23,835	33,993	47,523	0	0	0	23,835	33,993	47,523	0	0	0	23,835	33,993	47,523
	E-5	22,955	35,125	50,265	0	0	0	22,955	35,125	50,265	0	0	0	22,955	35,125	50,265
	Sub Total	96,858	153,819	258,872	0	0	0	96,858	153,819	258,872	0	0	0	96,858	153,819	258,872
District F	F-1	10,153	17,591	26,865	0	0	0	10,153	17,591	26,865	0	0	0	10,153	17,591	26,865
	F-2	6,180	10,707	16,353	0	0	0	6,180	10,707	16,353	0	0	0	6,180	10,707	16,353
	F-3	4,988	8,615	13,176	0	0	0	4,988	8,615	13,176	0	0	0	4,988	8,615	13,176
	Sub Total	21,321	36,913	56,394	0	0	0	21,321	36,913	56,394	0	0	0	21,321	36,913	56,394
District G	G-1	10,748	18,185	33,047	0	0	0	10,748	18,185	33,047	0	0	0	10,748	18,185	33,047
	G-2	17,438	28,970	46,307	0	0	0	17,438	28,970	46,307	0	0	0	17,438	28,970	46,307
	G-3	8,281	12,485	18,677	0	0	0	8,281	12,485	18,677	0	0	0	8,281	12,485	18,677
	G-4	26,514	37,637	50,569	0	0	0	26,514	37,637	50,569	0	0	0	26,514	37,637	50,569
	FSA 1	0	0	0	38,283	65,325	118,389	38,283	65,325	118,389	0	0	0	38,283	65,325	118,389
	Sub Total	62,981	97,277	148,600	38,283	65,325	118,389	101,264	162,602	266,989	0	0	0	101,264	162,602	266,989
	Total	1,039,429	1,390,856	1,913,712	51,382	85,662	143,721	1,090,811	1,476,518	2,057,433	10,394	13,909	19,137	1,101,205	1,490,427	2,076,570

(4) Wastewater Generartion by Sewer Sub-Catchment (Page 1 of 2)

(mld)

District	Sub-Catchment	Resident									Floating			Total		
		Inside of Municipality			Outside of Municipality			Total								
		2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030
District A	A-1	3.64	4.53	6.23	0.00	0.00	0.00	3.64	4.53	6.23	0.06	0.08	0.12	3.70	4.60	6.34
	A-2	1.51	1.89	2.63	0.00	0.00	0.00	1.51	1.89	2.63	0.02	0.03	0.05	1.53	1.93	2.67
	A-3	1.39	1.57	1.85	0.00	0.00	0.00	1.39	1.57	1.85	0.02	0.03	0.03	1.41	1.60	1.88
	A-4	6.69	5.87	5.33	0.00	0.00	0.00	6.69	5.87	5.33	0.10	0.10	0.10	6.80	5.97	5.43
	A-5	10.66	9.37	8.59	0.00	0.00	0.00	10.66	9.37	8.59	0.17	0.16	0.16	10.82	9.53	8.75
	A-6	5.54	6.13	6.64	0.00	0.00	0.00	5.54	6.13	6.64	0.09	0.10	0.12	5.62	6.23	6.76
	A-7	1.57	1.38	1.27	0.00	0.00	0.00	1.57	1.38	1.27	0.02	0.02	0.02	1.59	1.40	1.29
	A-8	6.24	5.48	5.02	0.00	0.00	0.00	6.24	5.48	5.02	0.10	0.09	0.09	6.33	5.57	5.11
	A-9	1.99	1.74	1.58	0.00	0.00	0.00	1.99	1.74	1.58	0.03	0.03	0.03	2.02	1.77	1.61
	A-10	12.78	12.56	12.92	0.00	0.00	0.00	12.78	12.56	12.92	0.20	0.21	0.24	12.98	12.78	13.16
	A-11	4.21	4.61	4.88	0.00	0.00	0.00	4.21	4.61	4.88	0.07	0.08	0.09	4.27	4.69	4.97
	A-12	3.38	2.98	2.73	0.00	0.00	0.00	3.38	2.98	2.73	0.05	0.05	0.05	3.43	3.03	2.78
	A-13	8.35	8.87	9.34	0.00	0.00	0.00	8.35	8.87	9.34	0.13	0.15	0.17	8.49	9.02	9.51
	A-14	7.50	7.42	7.64	0.00	0.00	0.00	7.50	7.42	7.64	0.12	0.13	0.14	7.62	7.55	7.78
	Sub Total	75.44	74.41	76.61	0.00	0.00	0.00	75.44	74.41	76.61	1.18	1.26	1.42	76.62	75.67	78.04
District B	B-1	14.79	18.41	22.45	0.00	0.00	0.00	14.79	18.41	22.45	0.23	0.31	0.42	15.02	18.72	22.87
	B-2	6.89	9.49	13.89	0.00	0.00	0.00	6.89	9.49	13.89	0.00	0.00	0.00	6.89	9.49	13.89
	FSA 2	0.00	0.00	0.00	2.69	3.56	3.93	2.69	3.56	3.93	0.00	0.00	0.00	2.69	3.56	3.93
	Sub Total	21.68	27.90	36.34	2.69	3.56	3.93	24.37	31.46	40.27	0.23	0.31	0.42	24.60	31.77	40.69
District C	C-1	4.52	6.18	8.30	0.00	0.00	0.00	4.52	6.18	8.30	0.00	0.00	0.00	4.52	6.18	8.30
	C-2	3.49	4.83	6.50	0.00	0.00	0.00	3.49	4.83	6.50	0.00	0.00	0.00	3.49	4.83	6.50
	C-3	7.24	8.85	11.84	0.00	0.00	0.00	7.24	8.85	11.84	0.00	0.00	0.00	7.24	8.85	11.84
	C-4	3.62	3.47	3.54	0.00	0.00	0.00	3.62	3.47	3.54	0.00	0.00	0.00	3.62	3.47	3.54
	C-5	4.33	4.45	4.84	0.00	0.00	0.00	4.33	4.45	4.84	0.00	0.00	0.00	4.33	4.45	4.84
	Sub Total	23.20	27.77	35.02	0.00	0.00	0.00	23.20	27.77	35.02	0.00	0.00	0.00	23.20	27.77	35.02

(4) Wastewater Generartion by Sewer Sub-Catchment (Page 2 of 2)

(mld)

District	Sub-Catchment	Resident									Floating			Total		
		Inside of Municipality			Outside of Municipality			Total								
		2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030
District D	D-1	1.43	1.81	2.54	0.00	0.00	0.00	1.43	1.81	2.54	0.02	0.03	0.05	1.45	1.84	2.58
	D-2	2.36	2.82	3.77	0.00	0.00	0.00	2.36	2.82	3.77	0.04	0.05	0.07	2.39	2.87	3.84
	D-3	2.04	2.63	3.76	0.00	0.00	0.00	2.04	2.63	3.76	0.03	0.04	0.07	2.07	2.67	3.83
	D-4	3.60	4.35	5.33	0.00	0.00	0.00	3.60	4.35	5.33	0.06	0.07	0.10	3.65	4.42	5.43
	D-5	1.11	1.40	1.95	0.00	0.00	0.00	1.11	1.40	1.95	0.02	0.02	0.04	1.13	1.43	1.99
	D-6	0.50	0.64	0.88	0.00	0.00	0.00	0.50	0.64	0.88	0.01	0.01	0.02	0.51	0.65	0.90
	D-7	0.81	1.05	1.51	0.00	0.00	0.00	0.81	1.05	1.51	0.01	0.02	0.03	0.82	1.06	1.54
	D-8	2.58	3.46	4.76	0.00	0.00	0.00	2.58	3.46	4.76	0.04	0.06	0.09	2.62	3.52	4.85
	D-9	2.43	3.10	4.36	0.00	0.00	0.00	2.43	3.10	4.36	0.04	0.05	0.08	2.47	3.15	4.44
	D-10	4.34	4.37	4.85	0.00	0.00	0.00	4.34	4.37	4.85	0.07	0.07	0.09	4.41	4.44	4.94
	D-11	5.02	5.26	5.20	0.00	0.00	0.00	5.02	5.26	5.20	0.08	0.09	0.10	5.10	5.35	5.30
	D-12	2.62	2.65	2.69	0.00	0.00	0.00	2.62	2.65	2.69	0.04	0.04	0.05	2.66	2.70	2.74
	D-13	1.83	1.61	1.48	0.00	0.00	0.00	1.83	1.61	1.48	0.03	0.03	0.03	1.85	1.63	1.50
	D-14	7.52	6.90	6.76	0.00	0.00	0.00	7.52	6.90	6.76	0.12	0.12	0.13	7.63	7.02	6.89
	D-15	3.60	4.35	5.33	0.00	0.00	0.00	3.60	4.35	5.33	0.06	0.07	0.10	3.65	4.42	5.43
	D-16	4.02	4.37	5.26	0.00	0.00	0.00	4.02	4.37	5.26	0.06	0.07	0.10	4.08	4.45	5.36
	D-17	9.82	12.17	16.32	0.00	0.00	0.00	9.82	12.17	16.32	0.00	0.00	0.00	9.82	12.17	16.32
	Sub Total	55.62	62.92	76.75	0.00	0.00	0.00	55.62	62.92	76.75	0.72	0.86	1.12	56.34	63.78	77.87
District E	E-1	4.72	7.35	13.79	0.00	0.00	0.00	4.72	7.35	13.79	0.00	0.00	0.00	4.72	7.35	13.79
	E-2	2.37	3.23	4.94	0.00	0.00	0.00	2.37	3.23	4.94	0.00	0.00	0.00	2.37	3.23	4.94
	E-3	3.18	4.24	6.23	0.00	0.00	0.00	3.18	4.24	6.23	0.00	0.00	0.00	3.18	4.24	6.23
	E-4	4.89	5.95	7.37	0.00	0.00	0.00	4.89	5.95	7.37	0.00	0.00	0.00	4.89	5.95	7.37
	E-5	4.71	6.15	7.79	0.00	0.00	0.00	4.71	6.15	7.79	0.00	0.00	0.00	4.71	6.15	7.79
	Sub Total	19.86	26.92	40.13	0.00	0.00	0.00	19.86	26.92	40.13	0.00	0.00	0.00	19.86	26.92	40.13
District F	F-1	2.08	3.08	4.16	0.00	0.00	0.00	2.08	3.08	4.16	0.00	0.00	0.00	2.08	3.08	4.16
	F-2	1.27	1.87	2.53	0.00	0.00	0.00	1.27	1.87	2.53	0.00	0.00	0.00	1.27	1.87	2.53
	F-3	1.02	1.51	2.04	0.00	0.00	0.00	1.02	1.51	2.04	0.00	0.00	0.00	1.02	1.51	2.04
	Sub Total	4.37	6.46	8.74	0.00	0.00	0.00	4.37	6.46	8.74	0.00	0.00	0.00	4.37	6.46	8.74
District G	G-1	2.20	3.18	5.12	0.00	0.00	0.00	2.20	3.18	5.12	0.00	0.00	0.00	2.20	3.18	5.12
	G-2	3.57	5.07	7.18	0.00	0.00	0.00	3.57	5.07	7.18	0.00	0.00	0.00	3.57	5.07	7.18
	G-3	1.70	2.18	2.89	0.00	0.00	0.00	1.70	2.18	2.89	0.00	0.00	0.00	1.70	2.18	2.89
	G-4	5.44	6.59	7.84	0.00	0.00	0.00	5.44	6.59	7.84	0.00	0.00	0.00	5.44	6.59	7.84
	FSA 1	0.00	0.00	0.00	7.85	11.43	18.35	7.85	11.43	18.35	0.00	0.00	0.00	7.85	11.43	18.35
	Sub Total	12.91	17.02	23.03	7.85	11.43	18.35	20.76	28.46	41.38	0.00	0.00	0.00	20.76	28.46	41.38
	Total	213.08	243.40	296.63	10.53	14.99	22.28	223.62	258.39	318.90	2.13	2.43	2.97	225.75	260.82	321.87

Table 5.9 Calculated Future Wastewater Strength

		Condition	Ratio	BOD (mg)	
				Respective	Composite
District A	2015	Sewered	55%	257	190
		Via Nalas	45%	109	
	2030	Sewered	80%	290	254
		Via Nalas	20%	109	
District B	2015	Sewered	29%	257	153
		Via Nalas	71%	109	
	2030	Sewered	80%	290	254
		Via Nalas	20%	109	
District C	2015	Sewered	30%	257	153
		Via Nalas	70%	109	
	2030	Sewered	80%	290	254
		Via Nalas	20%	109	
District D	2015	Sewered	25%	257	146
		Via Nalas	75%	109	
	2030	Sewered	80%	290	254
		Via Nalas	20%	109	
District E	2015	Sewered			
		Via Nalas			
	2030	Sewered	50%	290	200
		Via Nalas	50%	109	
District F	2015	Sewered			
		Via Nalas			
	2030	Sewered	50%	290	200
		Via Nalas	50%	109	
District G	2015	Sewered	12%	257	127
		Via Nalas	88%	109	
	2030	Sewered	67%	290	230
		Via Nalas	33%	109	

Calculated Future Westawater Strength

		2003	2015	2030
Per capita wastewater	lcpd	205	175	155
Per capita BOD loading	g/d	45	45	45
BOD	mg/l	220	257	290

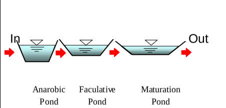
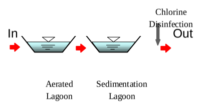
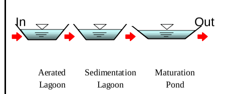
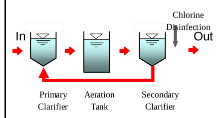
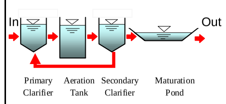
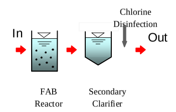
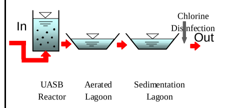
Measured Nala BOD Strength

Name of Nala	BOD(mg/l)
Salori Nala	75
Ghaghar Nala	144
Chachar Nala	164
Rajpur Nala	52
Average	109

District wise Overall Connecting Rate

	Year	Zone	Population	Connecting Rate	Pop. Connected	Overall Rate
District A	2015		432,397	55%	237,818	55%
	2030		503,469	80%	402,775	80%
District B	2015	B-1	106,995	50%	53,498	
		B-2	54,201	0%	0	
		FSA 2	20,337	0%	0	
		Total	181,533		53,498	29%
	2030	B-1	147,523	80%	118,018	
		B-2	89,633	80%	71,706	
		FSA 2	25,332	80%	20,266	
		Total	262,488		209,990	80%
District C	2015		158,714	30%	47,614	30%
	2030		225,944	80%	180,755	80%
District D	2015	Pumping	202,064	45%	90,929	
		Gravity	162,385	0%	0	
		Total	364,449		90,929	25%
	2030	Pumping	261,363	80%	209,090	
		Gravity	241,051	80%	192,841	
		Total	502,414		401,931	80%
District E	2015		153,819	0%	0	0%
	2030		258,872	50%	129,436	50%
District F	2015		36,913	0%	0	0%
	2030		56,394	50%	28,197	50%
District G	2015	Zone G	97,277	20%	19,455	
		FSA 1	65,325	0%	0	
		Total	162,602		19,455	12%
	2030	Zone G	148,600	80%	118,880	
		FSA 1	118,389	50%	59,195	
		Total	266,989		178,075	67%

Table 5.11 Qualitative Comparison of Treatment Process

		Treatment Method						
		WSP	AL	AL+	AS	AS+	FAB	UASB++
Process		Anarobic Pond +Faculative Pond +Maturation Pond	Aerated Lagoon +Sedimentation Lagoon +Chlorine Disinfection	Aerated Lagoon +Sedimentation Lagoon +Maturation Pond	Primary Clarifier +Aeration Tank +Secondary Clarifier +Chlorine Disinfection	Primary Clarifier +Aeration Tank +Secondary Clarifier +Maturation Pond	FAB reactor +Secondary Clarifier +Chlorine Disinfection	UASB reactor Aerated Lagoon +Sedimentation Lagoon +Chlorine Disinfection
Flow Sheet								
HRT (days)		14.0	5.5	9.5	0.5	4.5	0.2	4.3
		Anarobic Pond(1d) +Faculative Pond(7d) +Maturation Pond(6d)	Aerated Lagoon(3.5d) +Sedimentation Lagoon(2d) +Chlorine Disinfection	Aerated Lagoon(3.5d) +Sedimentation Lagoon(2d) +Maturation Pond(4d)	Primary Clarifier(4hr) +Aeration Tank(4hr) +Secondary Clarifier(4hr) +Chlorine Disinfection	Primary Clarifier(4hr) +Aeration Tank(4hr) +Secondary Clarifier(4hr) +Maturation Pond(4d)	FAB reactor(2hr) +Secondary Clarifier(2hr) +Chlorine Disinfection	UASB reactor(8hr) Aerated Lagoon(2d) +Sedimentation Lagoon(2d) +Chlorine Disinfection
Land area (ha/mld)		1.25	0.35	0.75	0.2	0.6	0.06	0.35
Cost	Capital costs (Rs.10^6/mld)	1.6	2.5	3.2	2.7	3.4	4.6	3.5
	M&E cost (% of total)	0.02	0.2	0.2	0.4	0.4	0.6	0.35
	Annual O&M (Rs.10^6/mld)	0.06	0.2	0.22	0.36	0.38	0.59	0.4
Sludge handling		Manual desludging once in several years, then dry on beds.	Manual desludging once in several years, then dry on beds.	Manual desludging once in several years, then dry on beds.	Fitst thicken and digest, then dry on beds.	Fitst thicken and digest, then dry on beds.	Fitst thicken, then directly dry on beds.	Directly dry on beds.
Operational characteristics		Simplest	Simple	Simple	Skilled operation required	Skilled operation required	Skilled operation required	Simpler than activated sludge
Energy requirement (except initial pumping)		Negligible	Lower than activated sludge	Lower than activated sludge	Highest	Highest	Highest	Lelatively low
Performance stability		Affected by temperature and seasonal changes. Not susceptivle to power failure.	Less affected by temperature and seasonal changes than WSP. But affected by power failure.	Less affected by temperature and seasonal changes than WSP. But affected by power failure.	Not affected by wastewater characteristices and seasonal changes. But adversely affected by power failure.	Not affected by wastewater characteristices and seasonal changes. But adversely affected by power failure.	Not affected by wastewater characteristices and seasonal changes. But adversely affected by power failure.	Not affected by wastewater characteristices and seasonal changes. Not susceptivle to power failure.
Resorce recovery	Sludge	Less potential for application because the sludge is not be produced on continuous basis.	Less potential for application because the sludge is not be produced on continuous basis.	Less potential for application because the sludge is not be produced on continuous basis.	Substantial quantity of sludge is produced and have potential for application to manure or soil conditioner.	Substantial quantity of sludge is produced and have potential for application to manure or soil conditioner.	Substantial quantity of sludge is produced and have potential for application to manure or soil conditioner.	Substantial quantity of sludge is produced and have potential for application to manure or soil conditioner.
	Biogas	No biogas is produced.	No biogas is produced.	No biogas is produced.	Biogas is produced and have potential for generating electricity or selling them to consumers.	Biogas is produced and have potential for generating electricity or selling them to consumers.	No biogas is produced.	Biogas is produced and have potential for generating electricity or selling them to consumers.

CHAPTER 6

EVALUATION OF ALTERNATIVES

CHAPTER 6 EVALUATION OF ALTERNATIVES

6.1 SUMMARY

Projected wastewater flows of 322 mld far exceed the present treatment capacity of 60 mld. Although the existing treatment plant at Naini can be expanded, the additional capacity is marginal (20 mld). It will therefore be necessary to build new treatment plants. The location of these treatment plants must be within reasonable proximity to the service area to minimize conveyance costs. Availability of land for STPs within Allahabad is limited.

Conveying sewage across the Ganga and Yamuna rivers to other locations over existing bridges has been explored but bridge authorities have not permitted the construction of rising mains. Crossing of rising mains from below the river bed has been rejected by the Study Team on the ground that it would be too expensive to construct proper foundations to anchor and protect the pipe lines from erosion damage, and it would be nearly impossible to maintain/repair the rising mains. Furthermore, leaks or large break downs in the rising mains could have serious environmental consequences.

Five alternative layouts have been evaluated in order to arrive at the most appropriate system design. These alternatives are presented in schematic form in Figures 6.1 to 6.5.

Each alternative has implications for the collection system, the sizing of pumping stations and capacity of new treatments plant. Conceptual development of the collection system and treatment plant requirements for each alternative is discussed and evaluated in the following sub-sections.

Alternative layouts are first screened through a qualitative evaluation using criteria such as reliability of operation, availability of land, ease of construction, and potential impact on water quality and downstream users. Alternatives that appear to be impractical, too difficult to construct, operate or maintain are screened out. The key focus for evaluating the remaining alternatives involves comparison of the estimated capital cost, and O&M cost to determine the least cost solution. Cost comparison tables for the alternatives are presented in this volume in Appendix B.

6.2 DESCRIPTION OF ALTERNATIVE LAYOUTS

Alternatives are identified with an understanding of the following constraints:

- Rising mains to Naini STP cannot be augmented.
- Naini STP can be augmented to 80 mld. However land is not available for construction of a second 80 mld treatment plant as proposed in the previous master plan.
- Rising mains cannot be installed on the new Yamuna bridge.
- Rising mains cannot be installed on the rail bridge crossing to Jhunsi
- Rising mains cannot be installed on the railway bridge or the road bridge crossing to Phaphamau.
- The sanctioned 29 mld Salori STP can be augmented to 101 mld in the future.

The concept of providing separate sewerage districts for the following areas was identified in the previous master plan and the same has been adopted again in the present Master Plan:

- Sulem Sarai area (District E)
- Phaphamau area (District F)
- Naini area (District G)

Sewerage in these 3 areas can be implemented as previously planned with the exception that the capacity and method of treatment will be different.

For the remaining central core areas, five major alternatives have been considered for qualitative evaluation. A description of each alternative is provided in the following paragraphs. Zone numbers used in the description of alternatives are those identified in the previous master plan.

6.2.1 Alternative I

Alternative I is presented schematically in Figure 6.1. This alternative is the closest to the previous master plan concept. The sewage from central Allahabad (District A, B and part of C) would be treated across the Yamuna river on the Naini side. Naini STP would be augmented to 80 mld and a new treatment plant would be constructed in Daini.

This alternative would involve three stages of pumping. The first stage of pumping would be from Alopibagh SPS to Gaughat MPS via the existing 900mm dia rising main, a distance of about 3,360 m. Alopibagh SPS would be reconstructed to accommodate a larger ultimate flow of 62 mld.

The second stage of pumping would be from Gaughat MPS. Here the flow would be split with 80 mld going across to Naini STP via the existing pumping station and rising main across the bridge. The remaining sewage flows of approximately 62 mld would be conveyed to Ghaghar nala SPS, a distance of about 4,200 m. A second pumping station would be constructed at Gaughat to convey the additional flows to Ghaghar nala SPS.

The third stage of pumping would be from Ghaghar nala SPS to Daini STP via a pressure main laid below the bed of the Yamuna river, a distance of about 3,000 m.

There is sufficient land in the Daini area to construct a waste stabilization pond. Total capacity required at the PS and STP will be 105 mld in 2030.
For District-D, there will be a new treatment plant of 20mld capacity at Rajapur.

6.2.2 Alternative II

Alternative II is presented schematically in Figure 6.2. This alternative corresponds closely to GAP-II proposals and assumes that the ultimate capacity of Salori STP will be 100 mld as proposed by UPJN. This alternative conveys sewage to a number of smaller, decentralized treatment plants.

Zone 1 (central) of the previous master plan would be divided into sewerage Districts A and B. Sewage from District A would be collected at existing Gaughat MPS and treated at Naini STP 80 mld. The sewage catchment area for District A would be configured to limit the total wastewater load to 80 mld, matching the capacity of Gaughat MPS and rising main to Naini STP.

Sewage from District B would be conveyed to a new FAB treatment plant located near Ghaghar nala at the 3.5 ha site proposed by UPJN. Flow from Ghaghar nala would be tapped, screened and conveyed by gravity to the new treatment plant.

Sewage from District C would be collected at Alopibagh SPS and pumped via a new rising main to Salori STP. Capacity at Alopibagh SPS would have to be augmented to handle increased ultimate flow of 62 mld.

6.2.3 Alternative III

Alternative III is presented schematically in Figure 6.3. This alternative is similar to Alternative II except the ultimate capacity of Salori STP would be limited to 35 mld while the STP proposed at Rajapur would be augmented to 80 mld. This alternative is proposed as a countermeasure to reduce the potential impact on downstream Sangam area in the event that the FAB treatment process at Salori STP is upset or by-passed during frequent and prolonged power outrages.

Zone 2 of the previous master plan would be divided into sewerage Districts C and D. The sewage catchment area for District C would be configured to limit the total wastewater load to 35 mld, matching the ultimate capacity of Salori STP.

Just over half the sewage flow from District D would be collected by gravity sewers draining to Alopibagh SPS, thereby making use of the existing sewer network. Wastewater would be conveyed via a new rising main to the new treatment plant proposed at Rajapur. A small increase in pumping capacity would be required at Alopibagh SPS for the estimated ultimate flow of 41 mld. The balance of wastewater flow would be collected by gravity sewers serving low lying areas around the treatment plant site and by a small catchment area draining to existing Mumfordganj SPS.

There is a large expanse of uninhabited land on the north side of Allahabad and therefore it should be possible to construct UASB treatment plant at Rajapur. Part of the area is prone to flooding however. It is assumed that the site can be graded and protected with berms. The site also provides an opportunity to use wetlands for polishing the effluent.

6.2.4 Alternative IV

Alternative IV is presented schematically in Figure 6.4. This alternative is similar to Alternative III except there would be no FAB treatment plant at Ghaghar nala. Instead, wastewater from District B would be treated in the Sulem Sarai area at Kodara STP. This alternative is proposed as a countermeasure to reduce the potential impact on downstream Sangam area in the event that the FAB treatment process at Ghaghar nala STP is upset or by-passed during frequent and prolonged power outages. In this alternative treated wastewater will be discharged to the Ganga river at about 27 km away from the Sangam.

Sewage from District B would be pumped in two stages. The first stage would be from a new pumping station near Sasur Khaderi river to Lukerganj SPS, a distance of 3,200 m. The second stage would be from Lukerganj SPS to the gravity sewer in Sulem Sarai area, a distance of 3,400 m. Capacity at Lukerganj SPS would have to be augmented to handle ultimate flows of 41 mld.

A pumping station would be constructed at Ghaghar nala outfall to tap nala flow and pump it into a gravity sewer that flows to Gaughat MPS in District A.

6.2.5 Alternative V:

Alternative V is presented schematically in Figure 6.5. This alternative is similar to Alternative IV except the wastewater from District B would be pumped across the Sasur Khaderi river to waste stabilization ponds to be located at a distance of approximately 7 km near Numaya Dahi. Treated effluent would be used for irrigation or discharged to the Yamuna river at about 12 km upstream of the raw water intake at Karelibagh.

6.3 QUALITATIVE COMPARISON OF ALTERNATIVES

This subsection of the report provides a qualitative comparison of alternatives. The relative merits of each alternative are discussed in the following paragraphs.

6.3.1 Evaluation Criteria

A series of factors are developed to provide qualitative evaluation for plan alternatives. These factors are:

- *Reliability* – The potential for mechanical and electrical failure of the system must be minimized by reducing the number of pumping stations and selecting treatment processes that can meet effluent criteria even under adverse operating conditions.
- *Compatibility* – All new options must be compatible with the existing system in order to minimize disruptions and cost.
- *Implementability* – The plan must minimize construction costs and have the ability to be phased into connection with the existing system. This allows for ease of construction and reduces the overall financial burden.
- *Impact on downstream users* – Treatment plant location and selection of process must reduce the negative impacts on water quality. Outfalls should not be located upstream of raw water intakes or within close proximity of religious bathing sites.
- *Treatment processes* – Processes that are easily upset by prolonged and frequent power outrages (e.g. activated sludge) are less favorable because they will not easily recover and have the potential to produce poor quality effluent day after day resulting in high pollutant loads. Alternatives that allow for more robust treatment processes such as waste stabilization ponds or aerated lagoons are more favorable.
- *Flexibility* – The plan should consider the ability to expand for future increased flows and be able to meet effluent criteria and potential future regulations.

6.3.2 Discussion of Relative Merits for Each Alternative

Alternative I

- This alternative requires a large capital investment for new pumping stations at Alopibagh, Gaughat and Ghaghar nala, as well as a significant cost for the construction of rising mains across the Yamuna river.
- The alternative will result in major disruption to the existing network and to the population. It requires laying of a new rising main in a congested area of the city and construction of a new pumping station adjacent to Gaughat MPS on a congested site.
- Crossing under the Yamuna river will require specialized civil engineering construction techniques and equipment and these will be costly. There is also a risk that such a rising main could be damaged during the flood season. Access to the rising main in case of leakage or blockage would be impossible.
- Conveyance of sewage through multiple stages of pumping will result in high operating and maintenance costs and will introduce many potential failure points.
- The number of pumping stations involved in conveying sewage to treatment makes this scheme vulnerable to raw sewage overflows during extended power failures or mechanical failures. These overflows would be discharged to Yamuna river upstream and within close proximity of the Sangam.
- Sufficient land is available across the Yamuna river to construct waste stabilization ponds which is considered the most reliable and easy to operate treatment processes as well as least susceptible to process upset.

Alternative II:

- This alternative requires no new pumping stations. However a major upgrade of sump and pumping capacity would be required at Alopibagh SPS.
- The investment cost for the FAB treatment process is the highest of all three alternatives
- The energy costs associated with FAB treatment will be the highest of all the alternatives.

- The FAB treatment process is reliable. However it is susceptible to upset after prolonged and repeated power failures. The quality of effluent could be affected by daily power outrages and could become a daily source of pollution directly upstream and within close proximity of Sangam.

Alternative III

- This alternative requires no new pumping station and makes use of existing pumping stations with minor upgrades to capacity.
- Sufficient land is available at Rajapur. Hence there is more flexibility to choose a simpler, more reliable and less costly treatment process such as aerated lagoons.
- The effluent from Rajapur would be discharged to the Ganga river approximately 14 km upstream the Sangam and would have less impact on water quality during power failures.
- The FAB treatment plant at Ghaghar nala will be expensive to construct and operate. It also has the potential of affecting water quality near the Sangam.

Alternative IV

- This alternative requires a new pumping station at Lukerganj to convey wastewater flow towards Sulem Sarai (District-E).
- The alternative eliminates the need for the FAB treatment plant at Ghaghar nala thereby reducing the investment cost and operating costs.
- Sufficient land may not be available for 75mld UASB at Kodara nala out fall in the Sulem Sarai area.
- Treated wastewater from Kodara STP would be discharged to Ganga river at 27 km upstream of the Sangam thereby reducing the potential impact of treatment upset on bathing water quality.

Alternative V

- This alternative requires less pumping than Alternative IV.
- The alternative eliminates the need for the FAB treatment plant at Ghaghar nala and reduces the size of UASB at Kodara thereby reducing the investment cost and operating costs.
- Land is available at Numaya Dahi for waste stabilization ponds
- Treated wastewater will be discharged 12 km upstream of the water supply intake. However the treatment process is stable and pathogens should be low because of the maturation ponds.

6.3.3 Evaluation of Alternatives for District C and D

Of the alternatives discussed previously only three alternatives affect the configuration of sewerage infrastructure in Districts C&D:

	Descriptions
Alternative I	Pump 62 mld to Gaughat MPS and provide new STP at Daini
Alternative II	Augment Salori STP to 100 mld
Alternative III	Augment Rajapur STP to 80 mld and keep Salori STP at 35 mld

Table 6.1 Qualitative Ranking of Sewerage Alternatives for District C & D

Item	Alternative I	Alternative II	Alternative III
Operational reliability	3	2	1
Compatibility	2	2	3
Implementability	3	2	1
Potential impact on downstream users	3	2	1
Stability of treatment process	1	3	2
Flexibility	3	1	2
Total	17	12	10
Overall Ranking	3	2	1

1 = most favorable 3= least favorable

Alternative I is considered the least favourable and therefore rejected on the grounds that it will be too costly and difficult to construct, operate and maintain. The other two alternatives are relatively close therefore a cost comparison between Alternative II and III has been made and final selection is made on the basis of a cost comparison of both options.

6.3.4 Evaluation of Alternatives for District A and B

Of the alternatives discussed previously four alternatives need be compared for Districts A and B.

	Descriptions
Alternative I	Pump 62 mld to Gaughat MPS and provide new STP at Daini
Alternative II, III	Provide 45 mld FAB STP at Ghaghar nala
Alternative IV	Pump wastewater from District B to STP at Kodara
Alternative V	Pump wastewater from District B to STP at Numaya Dahi

Table 6.2 Qualitative Ranking of Sewerage Alternatives for District A and B

Item	Alternative I	Alternative II, III	Alternative IV	Alternative V
Operational reliability	4	1	3	2
Compatibility	4	2	3	1
Implementability	4	3	2	1
Potential impact on downstream users	4	3	1	2
Stability of treatment process	1	4	3	2
Flexibility	3	4	2	1
Total	20	17	14	9
Overall Ranking	4	3	2	1

1 = most favorable   4= least favorable

Alternative I is the least favourable and therefore rejected on the grounds that it will be too costly and difficult to construct and operate and maintain. Alternative V is clearly the most favourable but a cost comparison with Alternative IV has been done before making a final selection.

6.4 SELECTION OF TREATMENT PROCESS FOR COMPARISON OF OPTIONS

The type of treatment process must be selected before proceeding with a cost comparison of options. The selection of treatment process is based on a life cycle cost comparison. Detailed cost comparisons for each treatment plant are presented in Appendix B. The following treatment capacities have been identified for the year 2030 based on population and wastewater generated by sewerage district. In general the most cost effective treatment process is aerated lagoon. Waste stabilization ponds have a slightly higher life cycle cost because the land requirement and cost require a large initial investment. The cost comparison for each treatment plant is presented in the following sub-sections.

Table 6.3 Summary of Treatment Capacities for Comparison of Alternatives

(mld)

STP		Alternative I	Alternative II	Alternative III	Alternative IV	Alternative V
Daini	P	105	-	-	-	-
Salori	S	35	100	35	35	35
Rajapur	P	20	20	80	80	80
Naini	A	80	80	80	80	80
Kodara	P	30	30	30	75	30
Ponghat	P	10	10	10	10	10
Ghaghar Nala	P	-	45	45	-	-
Numaya Dahi	P	-	-	-	-	50

A = augment existing P = proposed S = sanctioned

The following notes are applicable to the Tables for cost comparison of treatment options:

- Land costs: 40 lahks per ha (reported by UPJN Varanasi at Workshop on Feb 17 2004)
- Land area: taken from NRCD guidelines and review of existing STPs implemented under GAP
- Capital and O&M costs taken from a review of STPs implemented under GAP
- Present value based on 5% interest and 30 year life with replacement of mechanical equipment after 15 years
- WSP = Waste Stabilization Pond (including maturation ponds)
- FAB = Fluidized Aerated Bio-Reactor plus chlorine disinfection
- AS = Activated Sludge plus chlorine disinfection; + indicates maturation ponds
- AL= Aerated Lagoons plus chlorine disinfection; + indicates maturation ponds
- UASB++: Upflow Anaerobic Sludge Blanket with post treatment provided by aerated lagoons plus chlorine disinfection.

6.4.1 Rajapur STP

The comparison of costs indicates that UASB offers a slightly lower life cycle cost than waste stabilization ponds but the later has the lowest O&M cost. The land requirement for WSP is significant and it is doubtful that such a large site can be obtained. Therefore the Master Plan has adopted UASB for the comprehensive cost comparison of Alternatives II and III. Based on site visits and preliminary discussions with UPJN there should be sufficient land available near the Rajapur nala.

Table 6.4 Rajapur STP: Preliminary Cost Comparison of Process Alternatives

Cost (Rs. million)	WSP	AL	AL+	AS	AS+	FAB	UASB ++
	Alternative II, 20 mld						
Land area for treatment process (ha)	25	7	15	4	12	1.2	7
Land cost	100	28	60	16	48	5	28
Capital cost	32	50	64	54	68	92	60
Annual O&M	1.2	6.0	6.4	7.2	7.6	11.8	2.6
Life cycle cost (including land)	152	179	234	197	251	313	140
	Alternative III, 80 mld						
Land area for treatment process (ha)	100	28	60	16	48	4.8	28
Land cost	400	112	240	64	192	19.2	112
Capital cost	128	200	256	216	272	368	240
Annual O&M	4.8	24.0	25.6	28.8	30.4	47.2	10.4
Life cycle cost (including land)	607	719	934	764	1007	1255	560

6.4.2 Kodara STP

The comparison of costs indicates that UASB offers a slightly lower life cycle cost than waste stabilization ponds but the later has the lowest O&M cost. The land requirement for WSP is significant and it is doubtful that such a large site can be obtained therefore the Master Plan has adopted UASB for the comprehensive cost comparison of Alternatives III and V.

Table 6.5 Kodara STP: Preliminary Cost Comparison of Process Alternatives

Cost (Rs. million)	WSP	AL	AL+	AS	AS+	FAB	UASB ++
	Alternative III, 30 mld						
Land area for treatment process (ha)	37.5	10.5	22.5	6.0	18.0	1.8	10.5
Land cost	150	56	120	32	96	10	56
Capital cost	48	100	128	108	136	184	120
Annual O&M	1.8	9.0	9.6	10.8	11.4	17.7	3.9
Life cycle cost (including land)	227	269	350	294	377	471	210
	Alternative IV, 75 mld						
Land area for treatment process (ha)	93.8	26.3	56.3	15	45	4.5	26.3
Land cost	375	105	225	60	180	18	105
Capital cost	120	188	240	203	255	345	225
Annual O&M	4.5	22.5	24.0	27.0	28.5	44.3	9.8
Life cycle cost (including land)	569	673	876	737	944	1176	525

6.4.3 Numaya Dahi STP

The comparison of costs indicates that waste stabilization ponds offer the lowest O&M cost and it is assumed after site visits and discussions with UPJN that sufficient land can be obtained near the village Dahi for WSP. At this site, there is potential for discharge of effluent for irrigation. Furthermore, waste stabilization ponds are preferred here because when not used for irrigation, the effluent will be discharging to Yamuna river upstream of the water supply intake. Therefore the Master Plan has adopted WSP at Numaya Dahi STP for comprehensive cost comparison of options.

Table 6.6 Numaya Dahi STP: Preliminary Cost Comparison of Process Alternatives

Cost (Rs. million)	WSP	AL	AL+	AS	AS+	FAB	UASB ++
	Alternative V, 50 mld						
Land area for treatment process (ha)	62.5	17.5	37.5	10.0	30.0	3.0	17.5
Land cost	250	70	150	40	120	12	70
Capital cost	80	125	160	135	170	230	150
Annual O&M	3.0	15.0	16.0	18.0	19.0	29.5	6.5
Life cycle cost (including land)	379	449	583	491	629	784	350

6.4.4 Ghaghar Nala STP

Ghaghar nala STP would be of the same capacity as proposed at Numaya Dahi. Therefore the same cost comparison of process alternatives is applicable. The site selected by UPJN for the STP is only 3.5 ha and there are no other larger sites available near Ghaghar nala. Although it has the highest life cycle cost the Master Plan adopts FAB technology because it is the only one that can fit the site if Alternative II is selected.

6.4.5 Pumping Stations

The investment and operating costs at the following pumping stations will be affected depending on which alternative is selected. Capacities at major pumping facilities for each alternative are provided in Table 6.7.

Table 6.7 Summary of Pumping Requirements for Alternatives

(mld)

Pump Stations		Alt. I	Alt. II	Alt. III	Alt. IV	Alt. V
Alopibagh SPS	E	62	62	41	41	41
Gaughat SPS	E	80	80	80	80	80
Lukerganj SPS	E	23	23	23	41	23
Gaughat SPS	P	62	-	-	-	
Ghaghar Nala SPS	P	105	-	-		50
Sasur Khaderi SPS	P	18	18	18	18	-

The size and length of rising mains will be different for each alternative. Therefore the energy costs will also be affected. Preliminary selection of the most economic diameter of rising mains is based on calculations presented in Appendix B. While sizing of rising mains energy costs, supply and installation of pre-stressed concrete pipes, cost of pumps and annual maintenance costs have been considered.

6.5 COST COMPARISON AND SELECTION OF ALTERNATIVES

Alternative I is rejected by qualitative ranking because it is the least favorable solution. The cost comparison of remaining alternatives is grouped as follows:

- Alternative II vs. Alternative III: affecting the configuration of District C&D.
- Alternative IV vs. Alternative V: affecting the configuration of District B&E.

6.5.1 Cost Comparison Alternative II vs. Alternative III

A comparison of investment and O&M costs for treatment plants and pumping stations for Alternatives II and III is summarized in Table 6.8 and presented in more detail in Appendix B.

Table 6.8 Preliminary Cost Comparisons of Alternatives District C & D

Item	Alternative II	Alternative III
Capacity (mld)		
Salori STP	100	35
Rajapur STP	20	80
Alopibagh SPS	62	41
Life cycle cost (1)(Rs. million)		
Land	27	107
Capital	799	839
Annual O&M (2)	963	484
Total	1,789	1,430

(1) At 5% interest, 30 year life, and replacement of M&E components after 15 years
(2) Includes energy costs

The initial investment, the annual O&M costs of Alternative III are lower. Alternative III also has the best ranking in terms of qualitative criteria. Therefore the Master Plan has adopted Alternative III as the preferred solution for configuring sewerage Districts C and D.

6.5.2 Cost Comparison Alternative IV vs. Alternative V

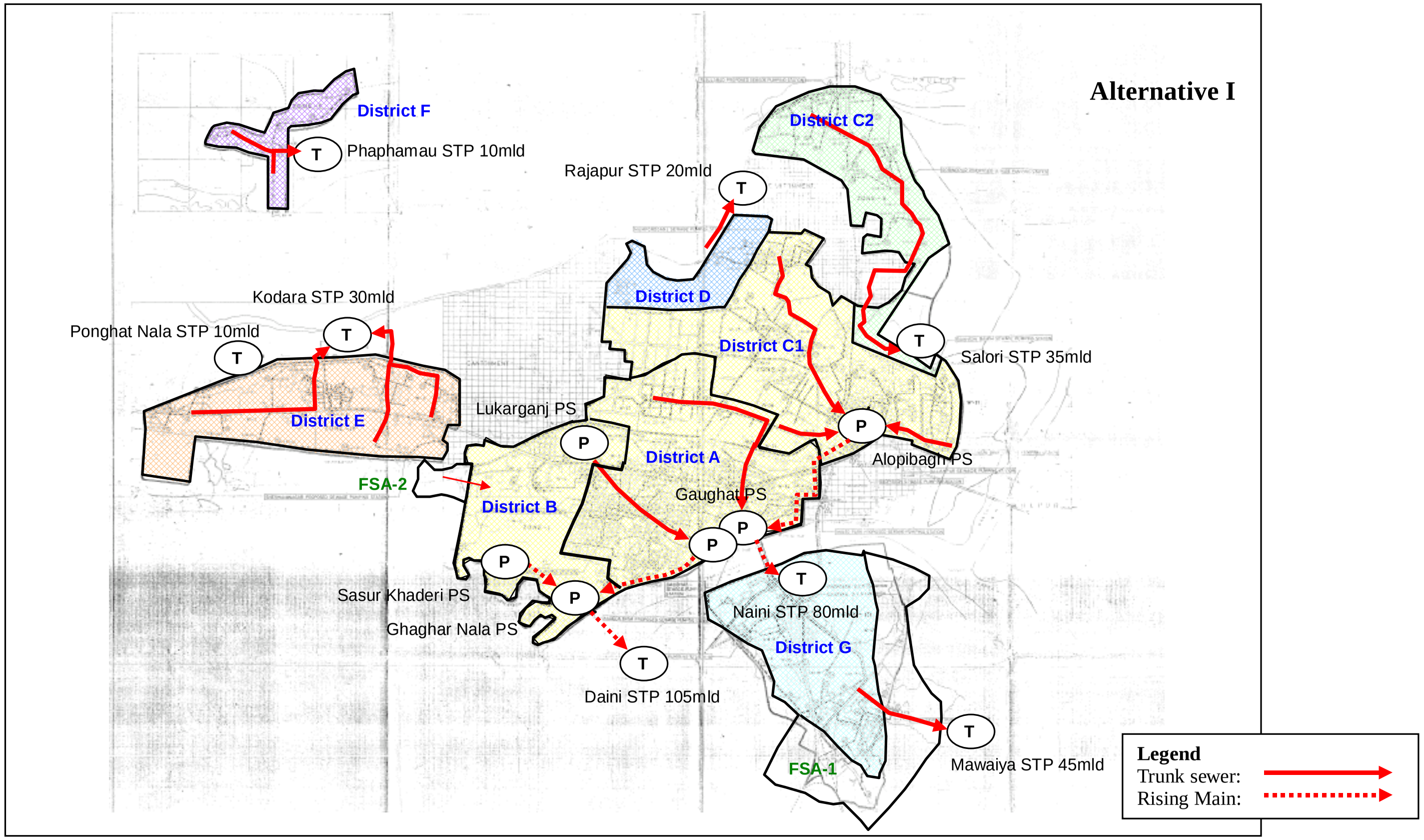
A comparison of investment and O&M costs for treatment plants and pumping capacities for Alternatives IV and V is summarized in Table 6.9 and presented in more detail in Appendix B.

Table 6.9 Preliminary Cost Comparisons of Alternatives District B & E

Item	Alternative IV	Alternative V
Capacity (mld)		
Numaya Dahi STP	-	45
Kodara STP Ponghat STP	85	40
Sasur Khaderi SPS	5	-
Ghaghar Nala SPS	18	41
Lukerganj SPS	41	23
Life cycle cost (1) (Rs. million)		
Land	125	279
Capital	403	387
Annual O&M (1)	188	144
Total	715	809

(1) At 5% interest, 30 year life, and replacement of M&E components after 15 years
(2) Includes energy costs

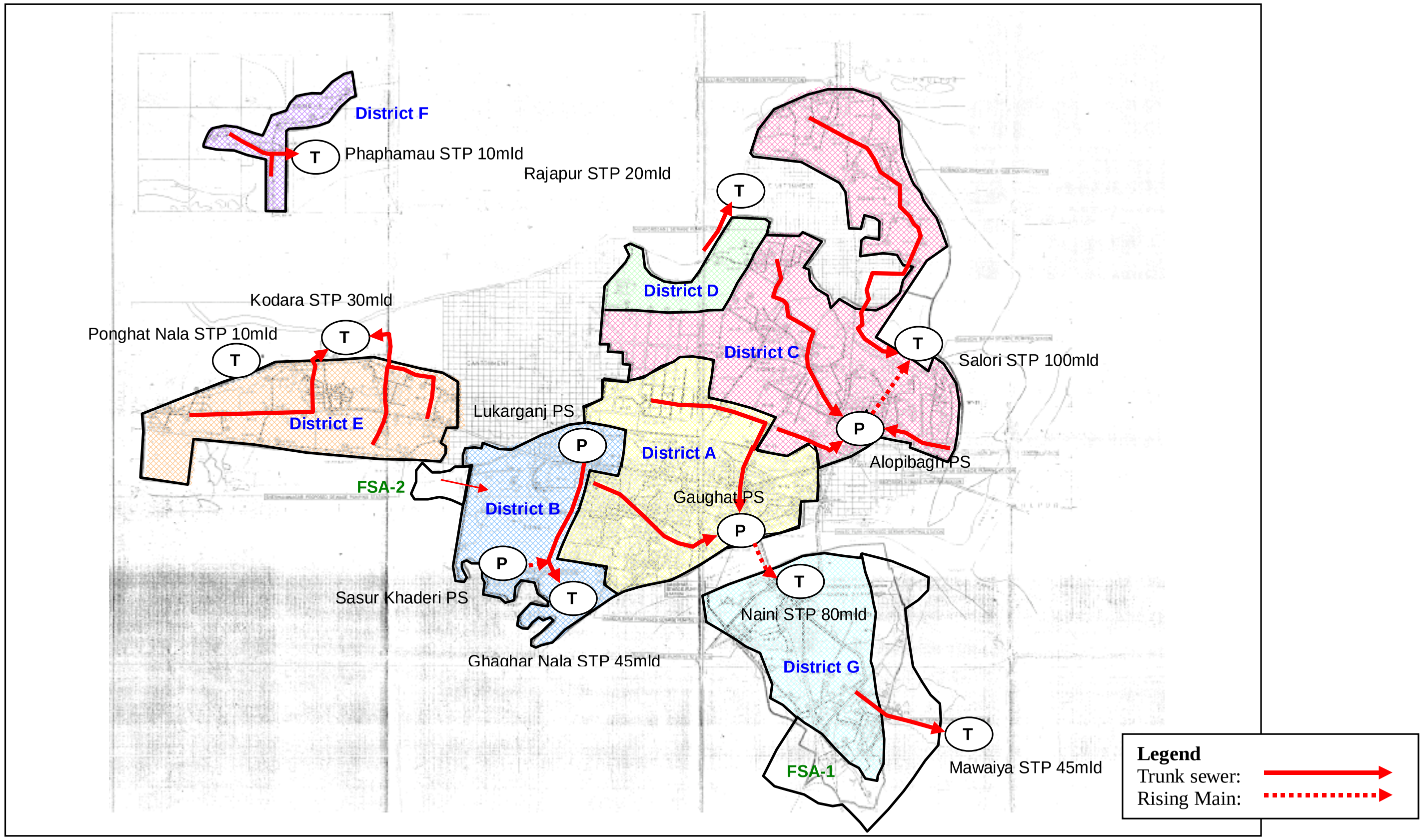
The life cycle cost of Alternative IV is slightly less than Alternative V because it has a lower land cost. However, the annual O&M cost for Alternative V is lower and it provides a more reliable and stable treatment process using WSP. Alternative V also scored better in the ranking of qualitative criteria. The Master Plan has adopted Alternative V as the preferred solution for configuring Sewerage Districts B and E.



	Population		Wastewater Gene. (mld)	
	2015	2030	2015	2030
District A	432,397	503,469	75.67	78.04
District B (Including FSA 2)	181,533	262,488	31.77	40.69
District C1	294,911	397,136	51.61	61.56
District C2	158,714	225,944	27.77	35.02
District D	69,538	105,278	12.17	16.32
District E	153,819	258,872	26.92	40.13
District F	36,913	56,394	6.46	8.74
District G (Including FSA 1)	162,602	266,989	28.46	41.38
Total	1,490,427	2,076,570	260.83	321.88

	Capacity (mld)		Remarks
	2015	2030	
Alopibagh PS	52	62	District C1
Gaughat PS (to Naini)	80	80	District A
Gaughat PS (to Ghaghar)	48	62	District A
Ghaghar Nala PS	80	105	District B
Naini STP	80	80	District A+B+C1
Daini STP	80	105	District A+B+C1
Salori STP	29	35	District C2
Rajapur	15	20	District D
Kodara STP	20	30	District E
Ponghat STP	10	10	District E
Phaphamau STP	10	10	District F
Mawaiya STP	30	45	District G
Total	274	335	

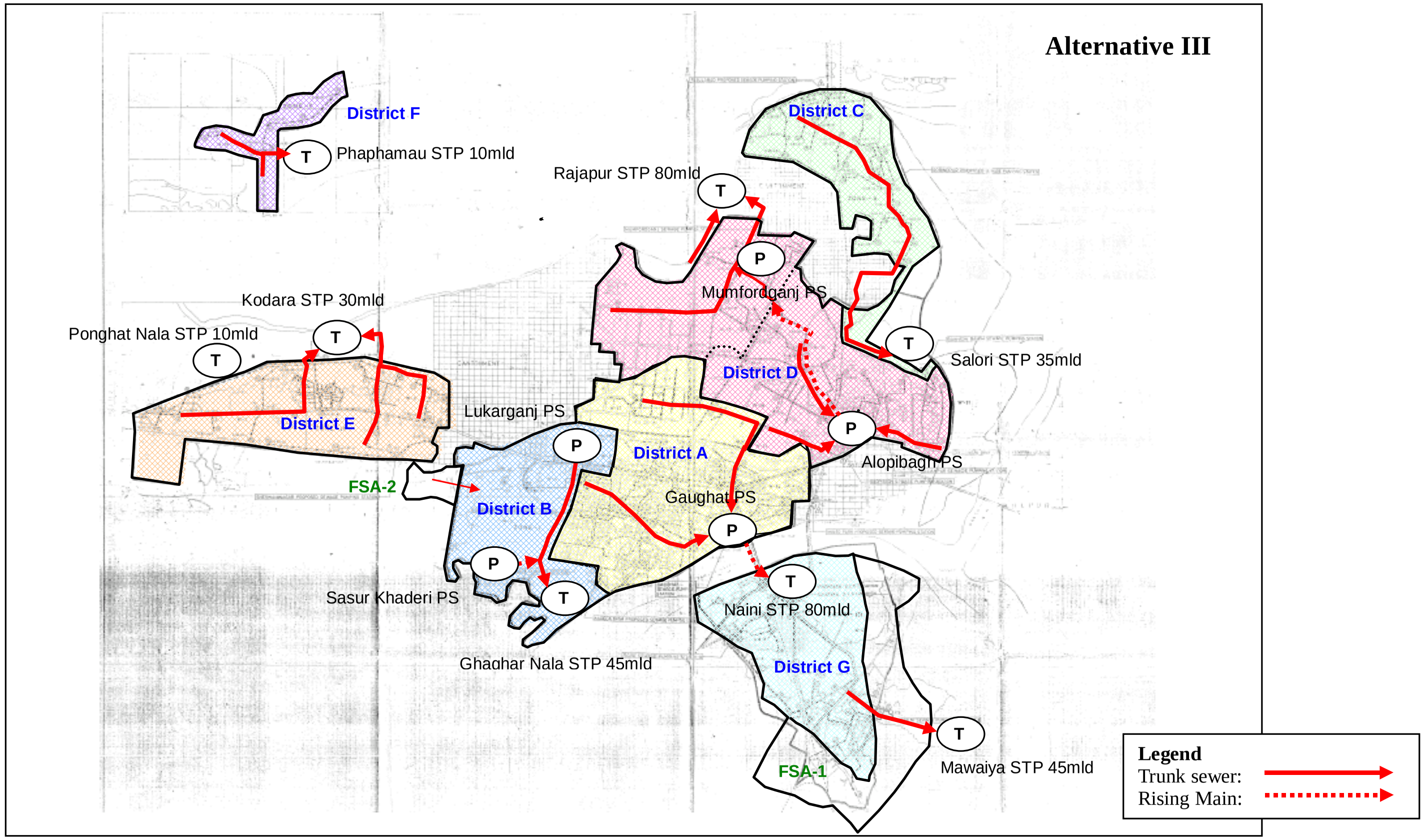
Figure 6.1 Sewer Layout: Alternative I



	Population		Wastewater Gene. (mld)	
	2015	2030	2015	2030
District A	432,397	503,469	75.67	78.04
District B (Including FSA 2)	181,533	262,488	31.77	40.69
District C	453,625	623,080	79.38	96.58
District D	69,538	105,278	12.17	16.32
District E	153,819	258,872	26.92	40.13
District F	36,913	56,394	6.46	8.74
District G (Including FSA 1)	162,602	266,989	28.46	41.38
Total	1,490,427	2,076,570	260.83	321.88

	Capacity (mld)		Remarks
	2015	2030	
Alopibagh PS	52	62	District C
Gaughat PS	76	80	District A
Lukarganj PS	19	23	District B
Naini STP	80	80	District A
Ghaghar Nala STP	35	45	District B
Salori STP	80	100	District C
Rajapur	15	20	District D
Kodara STP	20	30	District E
Ponghat STP	10	10	District E
Phaphamau STP	10	10	District F
Mawaiya STP	30	45	District G
Total	280	340	

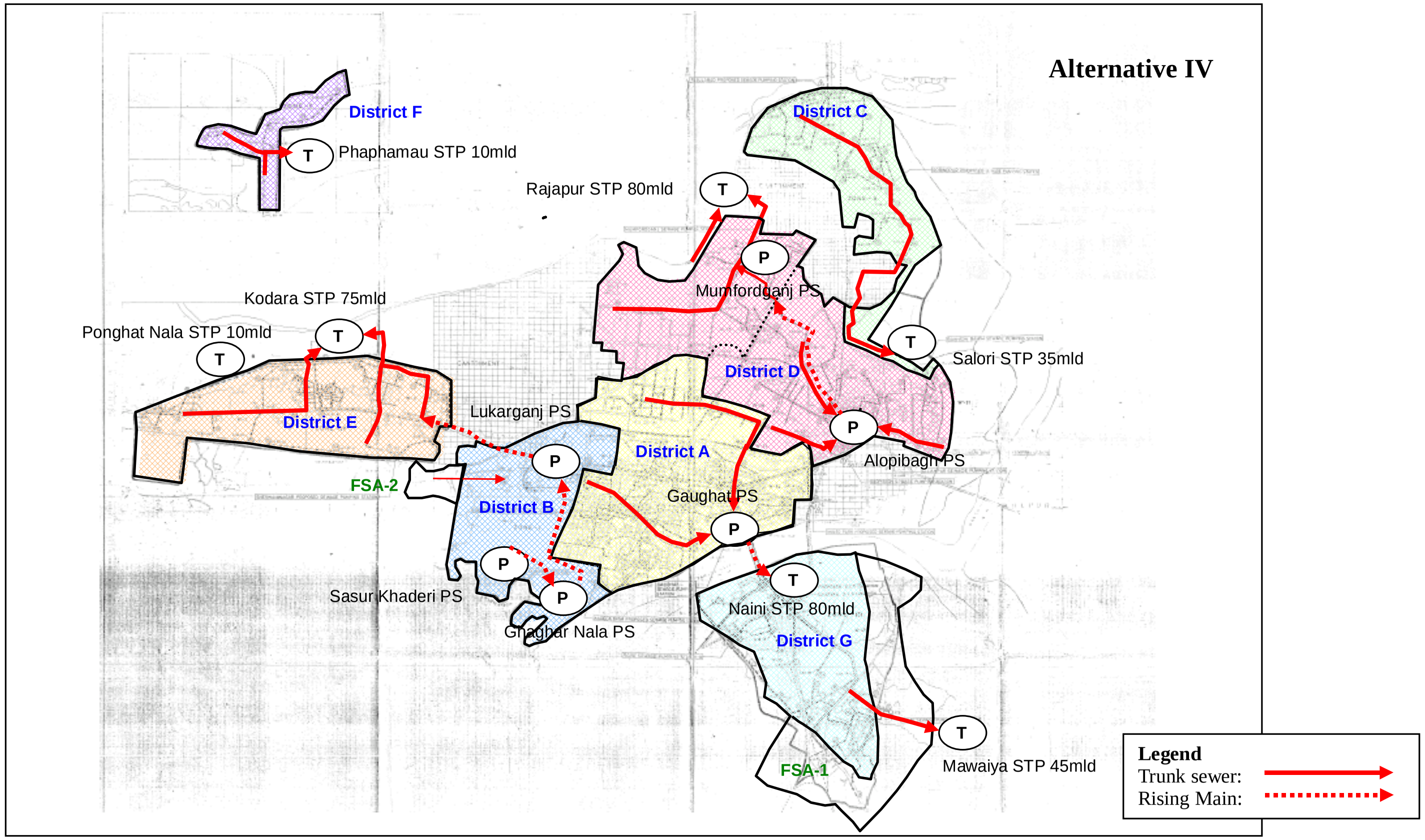
Figure 6.2 Sewer Layout: Alternative II



	Population		Wastewater Gene. (mld)	
	2015	2030	2015	2030
District A	432,397	503,469	75.67	78.04
District B (Including FSA 2)	181,533	262,488	31.77	40.69
District C	158,714	225,944	27.77	35.02
District D	364,449	502,414	63.78	77.87
District E	153,819	258,872	26.92	40.13
District F	36,913	56,394	6.46	8.74
District G (Including FSA 1)	162,602	266,989	28.46	41.38
Total	1,490,427	2,076,570	260.83	321.87

	Capacity (mld)		Remarks
	2015	2030	
Alopibagh PS	36	41	District D
Gaughat PS	76	80	District A
Lukarganj PS	19	23	District B
Naini STP	80	80	District A
Ghaghar Nala STP	35	45	District B
Salori STP	29	35	District C
Rajapur	65	80	District D
Kodara STP	20	30	District E
Ponghat STP	10	10	District E
Phaphamau STP	10	10	District F
Mawaiya STP	30	45	District G
Total	279	335	

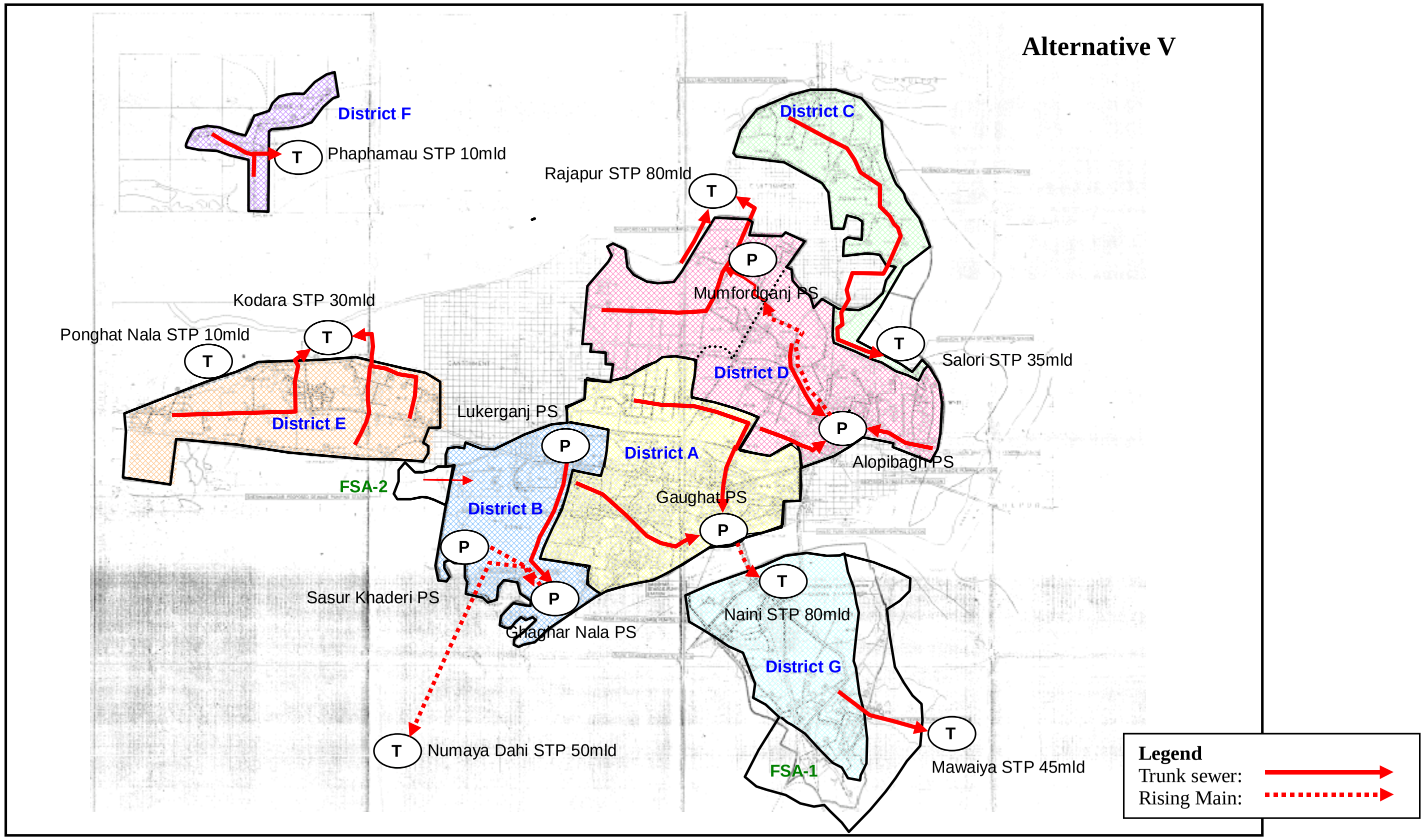
Figure 6.3 Sewer Layout: Alternative III



	Population		Wastewater Gene. (mld)	
	2015	2030	2015	2030
District A	432,397	503,469	75.67	78.04
District B (Including FSA 2)	181,533	262,488	31.77	40.69
District C	158,714	225,944	27.77	35.02
District D	364,449	502,414	63.78	77.87
District E	153,819	258,872	26.92	40.13
District F	36,913	56,394	6.46	8.74
District G (Including FSA 1)	162,602	266,989	28.46	41.38
Total	1,490,427	2,076,570	260.83	321.87

	Capacity (mld)		Remarks
	2015	2030	
Alopibagh PS	36	41	District D
Gaughat PS	76	80	District A
Lukarganj PS	32	41	District B
Sasur Khaderi PS	5	5	District B
Ghaghar Nala PS	13	18	District B
Naini STP	80	80	District A
Salori STP	29	35	District C
Rajapur	65	80	District D
Kodara STP	50	75	District B+E
Ponghat STP	10	10	District E
Phaphamau STP	10	10	District F
Mawaiya STP	30	45	District G
Total	274	335	

Figure 6.4 Sewer Layout: Alternative IV



	Population		Wastewater Gene. (mld)	
	2015	2030	2015	2030
District A	432,397	503,469	75.67	78.04
District B (Including FSA 2)	181,533	262,488	31.77	40.69
District C	158,714	225,944	27.77	35.02
District D	364,449	502,414	63.78	77.87
District E	153,819	258,872	26.92	40.13
District F	36,913	56,394	6.46	8.74
District G (Including FSA 1)	162,602	266,989	28.46	41.38
Total	1,490,427	2,076,570	260.83	321.87

	Capacity (mld)		Remarks
	2015	2030	
Alopibagh PS	36	41	District D
Gaughat PS	76	80	District A
Lukarganj PS	19	23	District B
Sasur Khaderi PS	5	5	District B
Ghaghar Nala PS	32	45	District B
Naini STP	80	80	District A
Numaya Dahi STP	35	50	District B
Salori STP	29	35	District C
Rajapur STP	65	80	District D
Kodara STP	20	30	District E
Ponghat STP	10	10	District E
Phaphamau STP	10	10	District F
Mawaiya STP	30	45	District G
Total	279	340	

Figure 6.5 Sewer Layout: Alternative V

CHAPTER 7

PROPOSED MASTER PLAN

CHAPTER 7 PROPOSED MASTER PLAN

7.1 SUMMARY

This section describes the collection and treatment components of the future sewerage system based on the recommended Alternative V selected in the previous section. In addition, this section of the Master Plan evaluates current capacity, and existing deficiencies and identifies capacity of each component to handle projected wastewater flows over the planning horizon.

District wise delineation of the sewerage scheme is presented in Figure 7.1 for 2015 and Figure 7.2 for 2030. The overall sewerage scheme will consists of 7 separate sewerage Districts each with its own treatment plant:

- District A: Central core conveying sewage to existing Gaughat MPS and Naini STP,
- District B: From Lukerganj SPS to Ghaghar nala SPS conveying sewage upstream of Yamuna River to Numaya Dahi STP
- District C: Area north of cantonment conveying sewage to sanctioned Salori STP
- District D: Alopibagh SPS area conveying sewage to proposed Rajapur STP
- District E: West Allahabad conveying sewage to Kodara STP and Ponghat STP in Sulem Sarai area
- District F: Phaphamau area conveying sewage to Phaphamau STP
- District G: South of Yamuna river conveying sewage to proposed Mawaiya STP

Populations, and wastewater generated by sewerage district are presented in Planning Framework Section 5 Table 5.6. Sewage generation quantities have been computed considering tributary areas proposed under the Master Plan. These tributaries areas are presented in Table 5.6 and are also shown on layout drawings in Appendix C. Peak sewage generation volumes at various phase years have been computed on peak factors as per Chapter 5.

The design capacity for some pumping stations and treatment plants will depend on how much flow is diverted from surface drains and nalas. Table 7.2 provides a model for predicting future nala flows. Flow in the nalas depends on two variables: sewer connection ratio and catchment area contributing to the nala. Calculated flows are compared to measured flows for calibration. The model is useful since it can be used to evaluate the impact of improved connection ratios on the flow in the nalas.

Hydraulic calculations for evaluating capacity of existing trunk sewers are presented in Table 7.3. Calculations for sizing proposed trunk sewers are presented in Table 7.4.

Existing pumping station data is presented in Table 7.6. Evaluation of pumping station capacity for present and future wastewater loads is presented in Tables 7.7.

7.2 STORM WATER DRAINS

Allahabad city has several large drains that carry significant amount of wastewater to Yamuna and Ganga rivers. These drains are also a significant source of pollution during wet weather when cow dung and human waste that accumulate during the dry season are flushed away by runoff.

Investigations were again carried out in the year 1998-99, and it has been found that drains discharge a total of 120 mld (35 drains discharge to Ganga river and 11 drains to Yamuna). A total of 7 drains (6 completely and 1 partly) have already been tapped in GAP-I diverting 90 mld.

Locations of existing nala/drains are shown in Fig. 7.3. A list of existing nalas/drains, including measured flows is shown in Table 7.1. Some drains have already been diverted to the sewer system. UPJN has proposed diverting the remaining nalas under GAP-II as shown in Drawing C2.

These nala-tapping arrangements are essential for intercepting wastewater during dry weather and reducing pollution load, however the present tapping arrangements are inadequate:

- They allow a substantial quantity of silt and debris into the sewer system which is detrimental to its life and proper functioning.
- They allow large quantities of storm water into the sewerage system which causes flooding and hydraulic overloads at treatment plant

Such nala tapping arrangements are considered as interim measures only and should be phased out gradually with the improvement in sewer coverage into all urban areas i.e. implementation of the Master Plan. However, house connection targets for 2030 are at most 80%. Therefore there will always be some flow in the nalas. It is recommended that each tapping point be provided with screening and grit removal facilities to protect the collection system. Furthermore each tapping point should have a means of automatically regulating the inflow during wet weather.

7.3 GENERAL ASSESSMENT: PHYSICAL CONDITION OF TRUNK SEWERS

A detailed survey of the trunk sewers was beyond the scope of the present Master Plan study. However the JICA team did carry out a visual survey of the trunk sewers at random locations to get an appreciation for potential problems. The visual surveys were supplemented by discussions with Jal Sansthan and Jal Nigam.

7.3.1 Current Deficiencies

1) Poor maintenance: The majority of the branch sewerage system is at any time either completely blocked or its capacity is severely reduced by silt and solid waste. Sewer maintenance is restricted to emergency clearing of blockages and is given low priority.

2) Silting and surcharging: Visual surveys by JICA study team indicates that sections of the trunk sewers are heavily silted. Reduced capacity from silting results in sewage overflows from manholes to surface drains during peak flow periods. Problems may also be caused by structural damage in some sections.

3) Ageing infrastructure: The existing trunk sewer system is over 75 years old and has been allowed to deteriorate to the point where rehabilitation or replacement is necessary. Many of the sewers have not been inspected.

4) Poor record keeping and inadequate information for planning: The limited availability of records relating to pumping stations and the sewerage system makes planning for extending services and assessing the amount of sewage presently flowing into the sewer system difficult. This also prevents effective maintenance and corrective actions.

5) Storm water and solid waste ingress to sewers: Damaged manholes, sewer defects particularly around the nala and connections of nala to the sewerage system have led to the increased risk of solid waste entering and blocking the system.

7.3.2 Current Capital Needs

Trunk sewers and branch sewers in the city need to be cleaned. Sewers that have been diverted to drains as a temporary relief from chronic blockage or surcharging should be re-instated and connected to the sewage collection system.

Drains that have been diverted directly into sewers must be rerouted to formal tapping points. These tapping points must be constructed with proper screening and grit removal facilities. Tapping points will also require some physical means of by-passing large stormwater flows. The present solution of manual gates is inadequate and creates operational difficulties.

7.4 SEWERAGE DISTRICT A

7.4.1 General Description

This area includes the old city core with an old sewerage network dating back to as early as 1910. Wastewater from this area is collected at Gaughat MPS and pumped through existing rising mains across the Yamuna railway bridge to Naini STP.

Defined under the previous master plan as Zone I, the sewerage network has been reconfigured under this Master Plan to provide a smaller catchment area that will not exceed the maximum capacity of Gaughat MPS and Naini STP (ultimate design capacity of 80 mld with expansion). Population densities in this area are generally greater than 300 persons per hectare and water distribution sufficiently good to support full coverage with sewerage.

Wastewater that does not enter the sewer system finds its way to Chachar nala, Ghaghar nala and many smaller tributary drains. Chachar nala flow is at present tapped and pumped to Gaughat MPS. Under the Master Plan a new pumping station is proposed to tap the tail end of Ghaghar nala.

7.4.2 Sewers

Details of the future sewer network are shown in Drawing C7. The carrying capacities of the existing sewers have been computed in accordance with Manning's formulae with values of 'n' = 0.017 corresponding to old brick sewers.

Carrying capacities of the new trunk sewers have been computed in accordance with Manning's formula with values of 'n' = 0.015 corresponding to concrete pipe. Sewage quantities are presented in Table 7.3, and Table 7.4 contains peak flows that the collection system has to sustain.

From the hydraulic analysis it is evident that several trunk sewers will not have sufficient hydraulic capacities even by the year 2015. Furthermore the trunk sewers are very old (Intalled in 1910) and reported to be in poor condition (refer sewerage master plan 1995).

Table 7.5 Proposed Sewer Replacement: District A

Sub-catchment	Node	Condition	Existing dia. (in)	Proposed dia. (mm)
A-1	A1 to A2	H	18”	700
A-2	A2 to A3	H	18”	700
A-3	A6 to A7	S	45”	700
A-4	A7 to Gaughat MPS	H	36” x 54”	1400
A-10	A10 to A12	H & S	22” x 33” and 54”	900
A-12	A12 to A13	S	22” x 33” and 54”	1200
A-13	A13 to Gaughat MPS	S	22” x 33” and 54”	1400

H = inadequate hydraulic capacity S = poor structural condition

Specific problem areas are identified as follows:

- The 22” x 33” sewer laid along Shaukat Ali Marg (node A9-A10-Gaughat MPS) and the parallel 54” sewer are very old and in poor physical condition. Furthermore section A10-Gaughat MPS does not have adequate hydraulic capacity. Both sewers should be replaced with a new single sewer of diameters, 900mm, 1200mm and 1400mm. Replacement should take place during Stage I

- The 36” x 54 “ sewer in Shahganj area is a combined rectangular sewer laid along Northern road. It is without accessibility and in very poor condition. In the new scheme it will be disconnected from the sewer system. New trunk sewers are proposed in the area. New sewers should be provided during Stage I
- The 39” and 45” trunk sewer laid along Grand Trunk road is in poor structural condition and should be replaced.
- All of the other older sewers laid around 1910 should gradually be replaced by new sewers of appropriate diameter during phase II.

Considering the congested situation of streets in the area the new sewers should be laid along the same alignment as old sewers wherever possible.

7.4.3 Chachar Nala Pumping Station (Existing)

The existing Chachar nala pumping station is located at the outfall of Chachar nala on the right bank of the nala. This pumping station was implemented under the Ganga Action Plan (GAP) to intercept wastewater from Chachar nala. The catchment of Chachar nala is included in the area of District A.

Wastewater is pumped through 2 rising mains: 1 x 600mm and 1 x 450mm, through a distance of 450m to the 54” diameter gravity sewer along Shaukat Ali Marg discharging into Gaughat pumping station.

A total of 5 pumps are installed with the following characteristics:

- 18,000 lpm 13m head – 3 nos.
- 3,470 lpm 13m head – 2 nos.

The total installed capacity is 1,016 lps and the allowable discharge with 50% de-rating is 677 lps. Anticipated peak sullage flows from the tributary of Chachar nala are of the order of :

- 787 lps in the year 2003,
- 594 lps in the year 2015 and
- 278 lps in the year 2030.

The present peak flow in the nala is less than allowable pumping capacity. The implementation of sewerage improvements should result in the reduction of nala flow. Therefore the pumping station has sufficient pump and rising main capacity if sewerage schemes are implemented as proposed.

The existing sump capacity of $65m^3$ provides for a holding time of only 1.8 minutes at peak sewage discharge in 2015 and is considered inadequate even with a reduction in nala flows. The sump must be enlarged by an additional 113 m^3 during Stage I.

Pumping station data is presented in Table 7.6 and an evaluation of pumping station capacities is presented in Tables 7.7.

Summary of Chachar Nala Pumping Station

Design flow	2015: 25.7 mld (average), 594 lps (peak)
	2030: 12.0 mld (average), 278 lps (peak)
Pump	18,000 lpm 13m head 3 nos.
	3,470 lpm 13m head 2 nos.
Allowable capacity	677 lps (50% de-rating)
Rising main	600 mm and 450 mm dia, L = 450 m

Sump Capacity	178 m^3 (Existing capacity is 65 m^3)

7.4.4 Gaughat Main Pumping Station (Existing)

Gaughat main pumping station is located near Yamuna bridge on the left bank of Yamuna river. At present this pumping station receives almost the entire volume of sewage collected by the sewerage system in Allahabad.

Under this Master Plan, this pumping station will receive all wastewater generated in District A, including wastewater intercepted at Chachar nala SPS.

The pumping station was designed for an ultimate average discharge of 80 mld and a peak flow of 1,852 lps. If the sewerage system is re-organized as indicated in the master plan, the average discharge in year of 2030 will be 74.4 mld. Therefore the existing firm pumping capacity is sufficient. Pumping station detailed data is presented in Table 7.6 and an evaluation of pumping station capacities is presented in Tables 7.7.

There are 5 pumps each one with a nominal discharge of 37,000 lpm x 35 m head. The station has a total installed capacity of 3,083 lps and an allowable pumping capacity of 1,850 lps with 3 out of 5 pumps in operation. The pumps are vertically aligned centrifugal pumps and frequently experience broken shafts from high torques developed when the pumps get clogged.

The pumping station has a sump capacity of 185 m^3. This capacity provide 1.8 minutes of storage at peak flow, which is less than the normally required 5 minutes. The sump must be enlarged by an additional 332 m^3 during Stage I.

Wastewater is discharged through 2 x 900mm dia C.I. rising mains in the initial stretches before reaching the bridge. The rising mains on the bridge section are C.I., bolted flange pipe, one of 27” and other of 36” dia. The crossing is about 1 km in length and the pipes are attached to the structure. The 27” dia rising main becomes 30” dia after crossing the Naini bridge and runs for a length of about 1.8 km up to the Inlet Chamber of Naini STP. The 36” dia rising main gets bifurcated into two mains after Naini bridge, one 30” dia of 1.85 km length up to Naini STP and the other 33” dia of 9.25 km length up to the chamber of Daini Sewage Farm. These two critical sections of the rising mains are reported to have a total safe carrying capacity of 1,840 lps which corresponds to ultimate design peak flow for Gaughat pumping station.

As stipulated by Railway Authorities, the sections of rising mains along the Naini bridge cannot be replaced by larger diameter pipe and as such the rising main becomes a constraint on the quantity of wastewater that can be conveyed across the Yamuna river.

Summary of Gaughat Main Pumping Station

Design flow	2015: 67.3 mld (average), 1,557 lps (peak)
	2030: 74.4 mld (average), 1,722 lps (peak)
Pump	37,000 lpm, 35m head 5 nos. (Existing)
Allowable capacity	1,850 lps (3 of 5 pumps in operation)
Rising main	27” and 36” dia, L = 1,500 m
Sump capacity	517 m^3 (Existing capacity is 185 m^3)

7.4.5 Naini Sewage Treatment Plant

(1) General

Projected flows based on populations in future service area are as follows:

- 2015: 67.3 mld (average)
- 2030: 74.4 mld (average)

This section includes information pertaining to the existing wastewater treatment plant at Naini. Data associated with the current facilities is limited because record keeping is poor. Physical processes and current loadings have been reviewed for capacity against design values.

Detailed analysis of plant process to identify potential improvements for optimizing performance of the present treatment plant is beyond the scope of the present Master Planning study. However some general observations are made on the basis of site visits and the limited operational data provided to the Study Team.

Future loadings to the plant have been projected to facilitate planning of future plant expansions. The analysis of present plant capacity and projected wastewater loadings aids in the development of alternatives for meeting future wastewater loadings. Preliminary alternatives for meeting future loadings have been developed for further consideration. The alternatives range from expansion of present facilities to constructing new treatment facilities.

A more detailed study and review of the treatment plants should be carried out before proceeding with any planned augmentations.

(2) Facility Overview

The work on this plant was initiated during February 1988 and it was fully commissioned in June 1994. The sewage treatment plant in Naini was designed with 3 x 20 mld modules giving a total capacity of 60mld. There is provision for an additional 20 mld module. Under the proposed Master Plan the treatment capacity will be augmented to 80 mld. This STP is operated and maintained by a contractor under the supervision of UP Jal Nigam. The laboratory is operated directly by UPJN.

The current process diagram is presented in Drawing C3 and it illustrates the major process units. The site plan presented in Drawing C4 provides an actual layout and location of the various process units.

As part of the master planning process it is important to understand the components that make up the treatment works and the associated capacities of each unit.

(3) Liquid Process Units

The present wastewater treatment process consists of two stages: primary treatment and secondary treatment. Each phase of treatment acts as a removal mechanism for targeted pollutants in the influent wastewater stream.

The wastewater flow enters the inlet collection chamber and preliminary treatment is carried out in the subsequent grit chamber. The flow is measured at the Parshall flume.

The flow is divided into three equal streams and enters circular primary clarifiers. In the primary clarifiers, not only some settleable solids but also some settleable organic load are removed from the bottom and conveyed to solids handling process with the sludge generated from secondary clarifiers. The current clarifiers appears to be in good condition and working efficiently.

Secondary treatment accomplishes the conversion of soluble organic material into settleable biomass by utilizing metabolic mechanism of micro organisms. The biomass is settled in final secondary clarifiers. At Naini STP, secondary treatment is accomplished with the conventional activated sludge process in three aeration tanks using surface aerators. The settled sludge is drawn off the bottom and pumped back to the primary clarifiers.

The various components of the liquid stream are listed by treatment stage. The condition of each component could not be assessed and will need to be evaluated during subsequent study. Furthermore some of the dimensional data required for process calculations is unavailable.

Table 7.9 Major Liquid Process Components

Level	Process	Component	Condition
Headwork	Inlet collection chamber	1 - 4.5m x 8.0m x 4.1m	Good
	Grit chamber	3 - 6.7m x 6.7m x 0.6m	Good
	Flow measurement	1 - Parshall flume	Good
Primary Treatment	Primary clarifiers	3– 31.0m diameter, SWD = 3.0m	Good
Secondary Treatment	Aeration tank	3 – 17.8m x16.6m, SWD = 3.9m	Good
	Secondary clarifiers	3 – 34.0m diameter, SWD = 3.0m	Good

(4) Solids Handling Units

Sludge consists of primary clarifier sedimentation and biological sludge from secondary clarifier, obtained after conversion of organic materials into cellular mass.

Biological sludge is entirely recirculated to the head of primary clarifiers. The combined sludge sedimented in the bottom of clarifiers is pumped to the sludge thickeners and conveyed to next stage i.e. sludge digesters.

Sludge entering the digesters is stabilized anaerobically where volatile fraction of the sludge is converted by bacteria into methane and water. There are no secondary digesters for separation and storage. The gas containing methane and CO_2 is utilized for the production of electricity.

Table 7.10 Major Solids Handling Components

Process	Component	Condition
Sludge thickener	2- 19.75m diameter, SWD = 3.0m	Good
Digesters	3 – 27.0m diameter, SWD = 4.8m	Good
Sludge drying beds	22 – 24.6m x 24.6m	Good

(5) Evaluation

Average monthly data made available to the Study Team is presented in Table 7.11. The average monthly inflow is 66 mld. The effluent quality data shows that average monthly BOD ranges from 29 to 31 mg/l and suspended solids from 40 to 43 mg/l. These values represent removal efficiencies of 78% and 89%, respectively. While there is no doubt that an activated sludge process can deliver better performance, the above values are rather close to the specified discharge limits. The corresponding monthly averages over a period of a year have a standard deviation of 1.25 indicating an unusually consistent performance, which is not so common in actual practice. On the whole the effluent has an acceptable aesthetic appearance and is used extensively for irrigation of vegetable crops.

An unusual feature of the liquid treatment scheme is return of secondary sludge to the primary clarifiers where it is co-settled with primary sludge and drawn off to the digesters. This is against the normal practice of wasting excess secondary sludge directly from the secondary clarifiers.

The present sludge-wasting arrangement has several disadvantages:

- It leads to re-suspension of settled sludge into the wastewater stream
- It leads to increased solids load on the primary clarifiers and thereby affects their removal efficiency,
- It leads to the onset of anaerobic digestion in the primary treatment stage which is exhibited by the presence of gas bubbles in the primary clarifiers,
- The gas bubbles inhibit proper settling and thereby reduce solids removal efficiency

Moreover, excess secondary sludge is wasted with primary sludge to a common thickener. This does not allow effective thickening of the two sludge streams, which have very different settling characteristics. This leads to higher hydraulic loading on the digesters. Normal practice is to provide separate thickeners for each sludge stream.

The sludge digesters are operated without temperature control, without insulation or sludge heating arrangements. As a result their performance varies from season to season giving sub-optimal biogas yield. Average biogas availability is about 3,200 m^3/day equivalent to 58 m^3/mld. The biogas desulpherisation unit has fallen into disrepair and is lacking the one step required to process the alkaline wastewater stream.

There is an elaborate cogeneration scheme involving dual fuel generators. However it is at present not utilized. Problems with the dual fuel generators include:

- Lack of funds for diesel fuel
- Electricity charges linked to contracted minimum load irrespective of actual consumption
- Inadequate quantity of biogas for meeting entire energy requirement of the plant
- Higher production cost using duel-fuel engine generators compared to cost of electricity supplied from the grid.

There is clearly no incentive for using biogas and therefore the total quantity of biogas is being flared.

Original process design calculations were not available to the Team and therefore design parameters are not known. A preliminary evaluation of the existing treatment plant process under future loading conditions will be required during subsequent study.

(6) Current Capital Improvement Needs

The digesters should be retrofitted to improve heat retention and temperature control.

The return and waste activated sludge lines and pump stations should be modified to allow wasting of secondary sludge directly from the secondary clarifier to the thickener. This will improve sludge settling in the primary tank. A separate thickener is required for secondary sludge.

The effluent does not meet current discharge limits for faecal coliform and some form of disinfection will be required. Since land appears to be limited, effluent chlorination will be the only feasible option.

7.5 SEWERAGE DISTRICT B

7.5.1 General Description

Identified as part of Zone I in the previous master plan, this district is west of District A from Ghaghar nala to Sasur Khaderi river. A small area lying north and west of Nurullah road is sewered and drains to Lukerganj SPS. The uninhabited area lying west towards Sasur Khaderi river is expected to grow quickly by 2015.

Wastewater that does not enter the sewer system finds its way to Ghaghar nala, Sasur Khaderi river and its tributary drains. Nala flow is at present untapped and discharging a large quantity of wastewater to Yamuna river.

7.5.2 Sewers

Details of the future sewer network are shown in Drawing C8. Carrying capacities of the new trunk sewers have been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to concrete pipes. Sewage quantities in Table 7.4 are peak flows that the collection system has to sustain.

Even before 2015, District A will not have sufficient capacity to absorb flows from District B. Therefore it will become necessary to divert wastewater from District B to Numaya Dahi STP via Ghaghar nala main pump station.

7.5.3 Lukerganj Pumping Station

The Lukerganj pumping station is located near boundary of District A and B in Lukerganj area. This pump station was commissioned in the year 1964 to handle the discharge from a 27" sewer catering to Lukerganj area. The pumping station discharges wastewater flow to the old 22" x 33" sewer on Shaukat Ali Marg, which is at present in poor condition and hydraulically overloaded. The discharge will be directed to a new gravity sewer leading to Ghaghar nala MPS.

At present the pumping station is equipped with the following pumps:

- 6,300 lpm discharge 7 m head 3 nos.
- 2,130 lpm discharge 7 m head 2 nos.

The total installed capacity is 386 lps and the allowable pumping capacity with 50% de-rating is 257. Anticipated peak flows from the catchment are of the order of:

- 104 lps in the year 2003,
- 217 lps in the year 2015 and
- 423 lps in the year 2030.

The allowable pumping capacity is sufficient to meet the present peak flow and that of the year 2015 but the ultimate peak flow exceeds the allowable pumping capacity.

The 44.5 m^3 sump provides only 1.8 minute holding time for the ultimate peak flow of 423 lps. The sump as such is considered inadequate for present and ultimate peak discharges. Under the Master Plan it is proposed to completely reconstruct this pumping station during Stage I (before 2015).

Existing pumping station data is presented in Table 7.6 and an evaluation of required pumping station capacities is presented in Table 7.7.
The new pumping station would have the following characteristics:

Design flow	2015: 9.4 mld (average), 217 lps (peak)
	2030: 18.3 mld (average), 423 lps (peak)
Pump (Initial stage)	6,300 lpm 13m head 3 nos.
	2,160 lpm 13m head 2 nos
Pump (Ultimate stage)	7,200 lpm 13m head 4 nos.
	3,600 lpm 13m head 3 nos
Allowable capacity	258 lps (50% de-rating) (Initial Stage)
	440 lps (50% de-rating) (Ultimate Stage)
Rising main	700 mm dia, L = 30 m
Sump capacity	127 m^3 (Existing capacity is 45 m^3)

7.5.4 Ghaghar Nala Pumping Station

The Ghaghar nala pumping station will be located near outfall of Ghaghar nala at its left bank. This pumping station will be the main pumping station receiving all the wastewater from District B. This pumping station will receive wastewater from Lukerganj pumping station and intercept Ghaghar nala. Coarse screens and grit removal facilities would be provided upstream of the pumping station. Wastewater would be conveyed via a 1,000 mm diameter rising main approximately 10 km to proposed Numaya Dahi STP. An evaluation of required pumping station capacities is presented in Tables 7.7 and economical selection of rising main is presented in Table 7.8.

Projected wastewater flows from District B, including Ghaghar nala flow are as follows:

Total design flow

- 2015: 46.4 mld (average), 1,075 lps (peak)
- 2030: 47.1 mld (average), 1090 lps (peak)

Anticipated peak flow of Ghaghar nala is expected to decrease over time with the implementation of sewerage improvements and house connection programs.

A total of 6 pump are proposed with the following characteristics:

- 10,800 lpm 6 nos.
- 8,400 lpm 4 nos.

The total installed capacity will be 1,640 lps with the allowable discharge with 50% de-rating as 1,093 lps. The sump capacity will be 327 m^3 to provide a holding time of 5 minutes at peak sewage discharge of year 2015.

7.5.5 Numaya Dahi STP

Projected flows based on populations in future service area are as follows:

- 2015: 46.4 mld (average)
- 2030: 47.1 mld (average)

The 50 mld Waste Stabilization Pond is recommended on the basis of detailed cost comparison of various treatment process options presented in Appendix B.

A WSP treatment plant will require approximately 63 ha of land including maturation ponds. A potential site has been identified near Numaya Dahi village with opportunities for discharge to agricultural irrigation.

7.6 SEWERAGE DISTRICT C

7.6.1 General Description

This district was identified in the previous master plan zone V (right bank). Wastewater from zone V has been reassigned to the Salori STP catchment since crossing the bridge to Phaphamau as previously proposed is not possible. The sewerage district wraps around the cantonment lands located to the east. At present the area has no sewers. Wastewater flows into Salori nala. UPJN has planned to tap and treat the nala flow at Salori STP. Thus the district boundaries correspond roughly to the natural catchment area of Salori nala.

7.6.2 Sewers

Details of the future sewer network are shown in Drawing C9. Carrying capacities of the new trunk sewers have been computed in accordance with Manning's formulae with value of "n" = 0.015 corresponding to concrete pipe. Sewage quantities in Table 7.4 are peak flows that the collection system has to sustain.

7.6.3 Salori STP

Projected flows based on populations in the sewerage district are as follows:

- 2015: 27.8 mld (average)
- 2030: 35.0 mld (average)

The construction of a 29 mld FAB technology treatment plant near Buxi bund has already been sanctioned. Design details of the treatment plant have not been worked out but the site plan and process diagram has been prepared by UPJN and are presented in Drawing C5 and C6. Wastewater will be pumped up at the head of the treatment plant, probably with screw pumps, before going through preliminary treatment. The effluent will be discharged to Salori nala after being chlorinated.

The plant will initially be constructed with 2 modules of 14.5 mld each. UPJN has planned to acquire a 9.5 ha site located in the Ganga River flood zone adjacent to Baxi bund road. The site will be raised and protected with a bund. The site is sufficiently large to eventually expand the treatment capacity to about 100 mld.

The sanctioned capacity will be adequate until around 2015. The Sewerage Master Plan estimates that the capacity should be augmented thereafter to around 35 mld to accommodate population growth in the District C catchment area. The additional land should be reserved for future growth beyond 2030 since suitable sites are difficult to acquire in this part of the city. Alternatively, Salori STP could be augmented to treat sewage flows from Kumbh Mela and other festivals which occur at the cantonment land near Sangam.

7.7 SEWERAGE DISTRICT D

7.7.1 General Description

This district was identified as Zone II in the previous master plan. The District D is subdivided into two zones. Zone D1 is the large area south of cantonment lands that is collected at Alopibagh SPS and discharged to Gaughat MPS. Zone D2 is the low-lying area north of GT road and west of Stanley road that drains to TV tower and Rajapur nalas.

The existing sewerage facilities in Zone D1 are of relatively newer construction and include intermediate pumping stations at, Daraganj, Allahpur, and Morigate. This zone is experiencing rapid growth and projected populations indicate that densities will be much greater than 300 persons per hectare before 2015. Therefore sewerage improvements are required in this area as soon as possible along with improvements in water supply. The present Master Plan proposes to redirect flows from Alopibagh SPS towards north for treatment at Rajapur STP via Mumfordganj MPS.

At present a small part of Zone D2 is sewered. Some part of the sewered area drains to Mumfordganj SPS and the remaining sewered area flows by gravity to Alopibagh SPS. Existing sewers in this zone will be reorganized to flow by gravity to proposed Rajapur STP via Mumfordganj MPS.

A large part of this area is occupied by low-density peri-urban settlements. It has recently experienced growth and is at present becoming urbanized. Wastewater flows are expected to increase with the recent extension of water supply services into the area.

7.7.2 Sewers

The sewers in Zone D1 (Alopibagh SPS catchment) are of relatively newer construction and most of the network can be used in the proposed scheme with minor modifications. They should be replaced or rehabilitated during the first stage before 2015 because they will be nearing the end of their useful life. The sewers in Zone D1 were laid in 1969-70 (earliest being in 1950-51) and are expected to function satisfactorily till 2030 if maintenance provisions are ensured.

Details of the future sewer network are shown in Drawing C10. The carrying capacities of the existing sewers have been computed in accordance with Manning's formulae with values of n = 0.017 corresponding to old brick sewers. Carrying capacities of the new trunk sewers have been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to concrete pipe Sewage quantities in Table 7.3, and 7.4 are peak flows that the collection system has to sustain.

From the hydraulic analysis it is evident that most of the existing sewer lines of this district will have sufficient carrying capacity. Short sections of gravity sewers will need to be replaced with larger diameter pipes as follows:

Table 7.12 Proposed Sewer Replacement: District D

Sub-catchment	Node	Reason for replacement	Existing dia. (inch)	Proposed dia. (mm)
D-6	D7 to D8	H	18	800
D-8	D-9 to D11	H	20	600
D-12	D13 to D15	H	18	700
D-13	D15 to Alopibagh SPS	H	321.6 mm 451.4 mm	1000

H = inadequate hydraulic capacity

7.7.3 Daraganj Pumping Station

This pumping station was constructed as a part of the Ganga Action Plan and was commissioned in 1988. It was designed to receive discharge from the newly laid Daraganj Ghat Sewer. This sewer has been laid to receive at present only sullage discharges from 18 small nalas conveying wastewater from a part of the Daraganj area. These nala tapping arrangements would gradually be replaced by proper sewerage system. Pumping station data is presented in Table 7.6 and an evaluation of pumping station capacities is presented in Tables 7.7.

At present the pumping station is equipped with the following pumps:

- 1,500 lpm discharge 22m head - 3 nos.
- 600 lpm discharge 22m head - 2 nos.

The total installed capacity is 95 lps and the allowable pumping capacity with 50% reserve capacity is 63.3 lps. Anticipated peak flows that this pumping station will receive are :

- 35 lps in the year 2003,
- 56 lps in the year 2015 and
- 98 lps in the year 2030.

The allowable pumping capacity is sufficient to meet the present peak flow and that of year 2015, but insufficient for the ultimate design flows.

The 25.8 m^3 sump provides 4.4 minute holding time for the present peak flow of 98 lps. The sump as such is considered adequate for present flows and slightly undersized for ultimate peak discharges. The upgraded pumping station would have the following characteristics:

- Pumps initial and ultimate stage: 3 x 6,300 lpm
  2 x 2,130 lpm
- Rising main: 600mm dia.

7.7.4 Allahpur Sewage Pumping Station

The pumping station was implemented as a part of Ganga Action Plan and is designed to cater to Allahpur area and a part of Daraganj area. Pumping station data is presented in Table 7.6 and an evaluation of pumping station capacities is presented in Tables 7.7.

At present the pumping station is equipped with the following pumps:

- 6,000 lpm capacity – 3 nos.
- 2,400 lpm capacity – 2 nos.

Total installed capacity is 380 lps and maximum allowable discharge is 253 lps with desired 50% standby provision. Anticipated peak flows at this pumping station are of the order of :

- 53 lps in the year 2003,
- 73 lps in the year 2015 and
- 128 lps in the year 2030.

The capacity is adequate to meet present and future peak flows. The 41.0 m^3 sump provides 5.4 minutes holding time at ultimate peak flow and is considered adequate.

Discharge from the pumping station is being conveyed by means of a 14” diameter rising main up to an existing 36” diameter sewer. The carrying capacity of this rising main is adequate to meet present and future requirements.

7.7.5 Morigate Sewage Pumping Station

The pumping station was implemented as a part of Ganga Action Plan and is designed to divert flows from Mori nala to Alopibagh pump station. The pump station has been constructed within the same site as the storm water pumping station and there is no space for expansion. Pumping station data is presented in Table 7.6 and an evaluation of pumping station capacities is presented in Tables 7.7.

At present the pumping station is equipped with the following pumps:

- 8,400 lpm capacity – 2 nos.

- 4,200 lpm capacity – 1 nos.

The total installed capacity is 350 lps and maximum allowable discharge is 233 lps with desired 50% standby provision. This capacity is insufficient to accommodate existing and projected nala flows. A new pumping station will be required across the road and just upstream of the existing site where open land is available. Projected peak flows in Mori nala are as follows :

- 786 lps in the year 2003,
- 696 lps in the year 2015 and
- 281 lps in the year 2030.

The existing rising main to Allopibagh has a diameter of 500mm. A second parallel rising main will be required to handle increased flows.

The new pumping station, sized to handle all of the flows, would have the following characteristics:

- Pumps initial stage and ultimate stage: 6 x 7,200 lpm
4 x 5,400 lpm
- Rising main: 500 mm dia (existing), 600mm dia (new)
- Sump capacity required: 209 m^3 (5 minutes retention, in 2015)

7.7.6 Alopibagh Sewage Pumping Station

The pumping station was originally commissioned in the year 1964 and renovated as a part of Ganga Action Plan. At present this pumping station receives liquid waste from Daraganj area, Tagore Town area, Alopibagh area, Sohbatia bagh and Tularambagh. The future subcatchment area will be reduced by the re-organization of the sewer system. The ultimate average daily flow will be 42.4 mld. An evaluation of required pumping station capacities is presented in Tables 7.7 and economical selection of rising main is presented in Table 7.13.

At present the pumping station is equipped with the following pumps:

- 11,300 lpm discharge 9m head 4 nos.
- 17,000 lpm discharge 10m head 3 nos.

The total installed pumping capacity is 1,603 lps and the maximum allowable discharge with 50% standby capacity is 1,069 lps. Projected peak flows are:

- 1,014 lps in the year 2003,
- 1,064 lps in the year 2015 and
- 1,031 lps in the year 2030.

The allowable capacity is sufficient to cater to the ultimate peak flow of 1,031 lps.

According to UPJN Allahabad, the 17 m^3 sump provides for a holding duration of 0.3 minutes at present peak flows and at ultimate peak flow, which is insufficient. An additional 292 m^3 of sump capacity will be required to achieve 5 minutes detention.

At present the discharge from Alopibagh pumping station is pumped through a 900 mm diameter rising main, approximately 3,600 m to Gaughat main pumping station. Under the Master Plan the discharge will be redirected through a new 1,000 mm diameter rising main approximately 2,500m to Mumfordganj MPS, then Rajapur STP.

7.7.7 Mumfordganj Pump Station

This pumping station was commissioned in the year 1968 and renovated under Ganga Action Plan. It is located in Zone D2. It receives sewage from a 32” dia sewer serving areas of Mumfordganj, Naya Katra, etc at present.

Under the Master Plan, this pumping station will become the main pumping station for District D, receiving sewage from Alopibagh SPS in addition to sewage from local branch sewers. Therefore, existing pumps and sump capacity will be insufficient for the design flow. The discharge from the pumping station will be conveyed to proposed Rajapur STP via a new rising main.

Pumping station data is presented in Table 7.6 and an evaluation of pumping station capacities is presented in Tables 7.7.

At present the pumping station is equipped with the following pumps:

- 6,800 lpm discharge 27m head – 2 nos.
- 1,350 lpm discharge 15m head – 2 nos.

The total installed pumping capacity is 272 lps and the maximum allowable discharge with 50% standby capacity is 181 lps. Projected peak flows are :

- 1,068 lps in the year 2003,
- 1,156 lps in the year 2015 and
- 1,420 lps in the year 2030.

The new pumping station would have the following characteristics:

- Pumps initial stage: 6 x 12,000 lpm
  4 x 8,400 lpm
- Pumps ultimate stage: 6 x 14,400 lpm
  4 x 10,800 lpm
- Rising main: 900 mm dia
- Sump capacity required: 426 m^3 (5 minutes retention)

7.7.8 Rajapur STP

Projected flows based on populations in the district are as follows:

- 67.4 mld in 2015
- 79.6 mld in 2030

An 80 mld UASB treatment plant with aerated lagoons for post treatment and chlorine disinfection is recommended on the basis of detailed cost comparison of various treatment process options presented in Appendix B. A potential 28 ha site has been identified near Rajapur nala but land is in the flood zone of Ganga river. Effluent will be discharged directly to the Ganga river after chlorination. In this case maturation ponds cannot be provided because they would take up too much land. There may be an opportunity to provide additional polishing by discharging the effluent to natural wetland along the Ganga river and this should be investigated in more detail in the subsequent study.

7.8 SEWERAGE DISTRICT E

This district is divided into three nala catchments, namely Ponghat nala to the west, Kodara nala (central), and Nehru Park nala to the east. As identified in the previous master plan, the sewage treatment plant is proposed near the outfall of Kodara nala, the largest of the three nalas.

It is not feasible to intercept and divert wastewater by gravity from Ponghat nala to Kodara STP because of deeply undulating topography. Therefore a small local STP is proposed at Ponghat nala in order to treat nala flow.

The catchment area for Nehru Park nala is quite large and is located mostly on cantonment board land. Only a small amount of the wastewater originates from District E. The Cantonment Board has created a huge pond at the tail end of the nala by constructing a check dam with overflow weir. The pond is at present overgrown with water hyacinth and already provides some level of treatment but it could possibly be improved by converting it into a natural wetland or even an aerated lagoon. There is at present insufficient information to determine how to proceed. Therefore this catchment area has not been included in this Master Plan study and it is recommended that the whole catchment area be studied in greater detail in some subsequent study. The study should determine topography, extent of the catchment area, drainage patterns, quantify populations and wastewater volumes, wastewater characteristics and assess the feasibility of natural treatment options. This study will need the full cooperation and involvement of the Cantonment Board.

7.8.1 Sewers

At present the area has no sewers. At ultimate stage all sewers will be connected to Kodara STP. However, interceptor sewer for tapping existing nalas should be installed on priority.

Details of the future sewer network are shown in Drawing C11. Carrying capacities of the new trunk sewers have been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to concrete pipes. Sewage quantities in Table 7.4 are peak flows that the collection system has to sustain.

7.8.2 Kodara STP

Projected flows based on populations inside the sewerage district boundary are as follows:

- 13.4 mld in 2015
- 29.3 mld on 2030

Projected flows do not include wastewater generated in the cantonment area which is discharged in the Nehru Park nala. A 30 mld UASB treatment plant with aerated lagoons for post treatment and chlorine disinfection is recommended on the basis of detailed cost comparison of various treatment process options presented in Appendix B. A potential 11 ha site has been identified near Kodara nala outfall but land is somewhat limited since the area is flood prone. In this case maturation ponds cannot be provided because they would take up too much land. Effluent will be discharged directly to the Ganga river after chlorination.

7.8.3 Ponghat STP

Projected flows based on populations in future service area are as follows:

- 7.4 mld in 2015
- 6.9 mld in 2030

A 10 mld waste stabilization pond is recommended on the basis of detailed cost comparison of various treatment process options

Table 7.14 Ponghat STP: Preliminary Cost Comparison of Process Alternatives

(million Rs.)

Item	WSP	AL	AL+	AS	AS+	FAB	UASB ++
Capacity (mld)	10	10	10	10	10	10	10
Land area for treatment process (ha)	12.5	3.5	7.5	2.0	6.0	0.6	3.5
Land cost	50	14	30	8	24	2	14
Capital cost	16	25	32	27	34	46	30
Annual O&M (per year)	0.6	3.0	3.2	3.6	3.8	5.9	1.3
Life cycle cost (including land)	76	90	117	98	126	157	70

A potential 13 ha site has been identified at the tail end of Ponghat nala. The nala runs below surrounding land and there appears to be an opportunity to use the natural topography to build a series of cascading lagoons along the same alignment of the stream. A more detailed topographic survey of the nala and surrounding areas will be required to determine the feasibility of converting the nala into a series of ponds.

Treated effluent would be discharged directly to the Ganga river. The effluent may be used for irrigation also in the fields adjoining the STP site.

7.9 SEWERAGE DISTRICT F

7.9.1 Sewers

At present the area has no sewers. Wastewater flows into several nalas identified in Figure 7.1. Details of the future sewer network are shown in Drawing C12. Carrying capacities of the new trunk sewers have been computed in accordance with Manning's formula with values of 'n' = 0.015 corresponding to concrete pipes. Sewage quantities in Table 7.4 are peak flows that the collection system has to sustain.

7.9.2 Phaphamau STP

Projected flows based on populations in future service area are as follows:

- 8.7 mld in 2030

A potential site has been identified but land is somewhat limited since the area is flood prone. Effluent will be discharged directly to the Ganga river.

A detailed comparison of various treatment process options is presented in Table 7.15.

Table 7.15 Phaphamau STP: Preliminary Cost Comparison of Process Alternatives

(million Rs.)

Item	WSP	AL	AL+	AS	AS+	FAB	UASB ++
Capacity (mld)	10	10	10	10	10	10	10
Land area for treatment process (ha)	12.5	3.5	7.5	2.0	6.0	0.6	3.5
Land cost	50	14	30	8	24	2	14
Capital cost	16	25	32	27	34	46	30
Annual O&M (per year)	0.6	3.0	3.2	3.6	3.8	5.9	1.3
Life cycle cost (including land)	76	90	117	98	126	157	70

The comparison indicates that UASB offers the lowest present value cost. However WSP is more practical given the relatively small size of treatment plant. The annual O&M cost of waste stabilization ponds is also much lower. It is assumed that UPJN can acquire the relatively small 13 ha site required for WSP. Therefore the Master Plan adopts WSP for preliminary cost estimates. Faecal coliform removal requirements for effluent will be met by a series of maturation ponds.

7.10 SEWERAGE DISTRICT G

7.10.1 Sewers

Proposed sewerage District G is largely un-sewered at present. Only a part of the area is covered by a network of small diameter sewers (6 to 12 inches) and a small pumping station that discharges to Naini STP. The existing sewer network is inadequate in size and coverage therefore it will be completely reconfigured to accommodate future growth and to provide gravity flow to a new sewage treatment plant to be located at Mawaiya.

Details of the future sewer network are shown in Drawing C13. Carrying capacities of the new trunk sewers have been computed in accordance with Manning’s formula with values of ‘n’ = 0.015 corresponding to concrete pipes. Sewage quantities in Table 7.4 are peak flows that the collection system has to sustain.

7.10.2 Mawaiya STP

Projected flows based on populations in future service area are as follows:

- 41.39 mld in 2030

A potential site has been identified near Mawaiya nala. Effluent will be discharged directly to the Ganga river. A detailed comparison of various treatment process options is presented in Table 7.16.

Table 7.16 Mawaiya STP: Preliminary Cost Comparison of Process Alternatives

(million Rs.)

Item	WSP	AL	AL+	AS	AS+	FAB	UASB ++
Capacity (mld)	45	45	45	45	45	45	45
Land area for treatment process (ha)	56.3	15.8	33.8	9.0	27.0	2.7	15.8
Land cost	225	63	135	36	108	11	63
Capital cost	72	113	144	122	153	207	135
Annual O&M (per year)	2.7	13.5	14.4	16.2	17.1	26.6	5.9
Total present value (including land cost)	341	404	525	442	566	706	315

The comparison indicates that UASB offers the lowest present value cost but not the lowest annual operating cost. WSP would require a 56 ha site and it is assumed that this much land will not be available in the area of the proposed site. The Master Plan adopts UASB treatment plant for preliminary cost estimates. Faecal coliform requirements for effluent will be met by chlorination.

7.11 JHUNSI AREA

Jhunsi is outside the Allahabad municipal area. However it is developing at a rapid pace and UPJN has expressed concern that it could soon be contributing significant pollutant loads to Ganga river. Figure 7.5 is a satellite image of the Jhunsi area. It depicts the location of settlements, and drains identified during site visits by the Study Team and UPJN.

Population has been estimated by UPJN as 60,000. This has been done by adjusting the 2001 census data for metropolitan Allahabad and arbitrarily assigning approximately 5% of the population to Jhunsi. Growth rate trends are not available and there is no data to indicate the spatial distribution of this population within the Jhunsi area.

The Study Team has tentatively divided the area into nala catchments. Using visual interpretation of the satellite image, the Study Team has assigned a population density to each catchment and thus derived a rough estimate of the population.

Table 7.17 Jhunsi Area Population by Nala Catchment

Catchment	Area (ha)	2003		2015		2030	
		Population	Person/ha	Population	Person/ha	Population	Person/ha
J1	286	15,712	55	21,426	75	28,568	100
J2	179	13,410	75	17,880	100	22,350	125
J3	398	13,916	35	21,867	55	29,819	75
J4	700	17,496	25	24,494	35	38,490	55
Total	1562	60,534		85,667		119,227	

There are four major nala catchments in this area, indicated as J1 to J4:

- J1 corresponds to the Shashtri bridge drain to the north of the Grand Trunk road. This area is divided by the NER railway line. Although it is urban in nature, the area is not densely populated except for a small pocket near the bridge.
- J2 corresponds to Lotey Haran drain to the south. This cacthment area also is urbanized at present and of higher population density. The area is contributing approximately 2 to 3 mld of wastewater flow to the Ganga river.
- J3 is at present sparsely populated and mostly rural in nature. The drain was dry during site visits in September. According to local residents, it only flows during wet weather. It is likely to stay rural in nature except for pockets of new colonies. These colonies may, in future, discharge to the nala which at present doesn't carry any wastewater flow.
- J4 is completely rural and located on the periphery of Jhunsi area to the south east. There is no urban growth projected in this area except for a small pocket at the very upstream extremity of the catchment.

There is insufficient water supply data to accurately calculate wastewater loads based on water consumption. However, an attempt has been made to quantify the potential magnitude of pollutant loads by making some simplifying assumptions. Future nala flows are assumed to be proportional to population growth. Thus, flow measurements taken by UPJN are extrapolated into the future using population growth. In the case of J3 and J4, there is no flow at present. Therefore future flow is calculated by assuming a future per capita wastewater contribution. Because of its rural nature, flow for J3 and J4 is calculated on the assumption that per capita water consumption will only be 75 lpcd on average with a return factor of 0.7.

Table 7.18 Jhunsi Area Nala Flows

Catchment	Nala Name	2003	2015	2030
		Measured* Flow (mld)	Estimated wastewater flow (mld)	
J1	Shashtri bridge	0.02	0.03	0.04
J2	Lotey Haran	2.15	2.9	3.9
J3	Name unknown	dry	1.1	1.6
J4	Name unknown	unkown	1.2	2.0
Total		2.17	4.03	5.54

*average flows measured by UPJN 1998/99

At this time the pollutant load is small and most of it is downstream of Sangam. Therefore pollution control interventions in this area are given a lower priority in the Master Plan. In future, depending on availability of funding, it is suggested that the larger drains be diverted to a small-scale treatment plant located to the south, near the outlet of J3. The capacity of facilities will depend on how much wastewater is generated into the drains. Therefore careful and frequent monitoring is required. Furthermore, in the absence of a sewage collection system, surface drains must be properly constructed and maintained to prevent unsanitary conditions.

Table 7.1 List of Existing Nala/ Drains in Allahabad

Area	No.	Name of Nala	Measured Discharge 1998-1999 (mld)	Expected Average Discharge 2005 (year) (mld)	2020 (year) (mld)	2035 (year) (mld)	Point of Discharge	Remark
ALLAHABAD CITY AREA	1	**MAIN GHAGHAR NALA**	40.00	40.00	50.00	64.00	Yamuna River (Left Bank)	8.68 mld waste water flow has already been tapped in GAP-I & is reaching to Gaughat MPS directly through existing sewer
	1A	**GHAGHAR NALA 1'A'**	4.00	4.00	5.00	6.50		
	1B	**GHAGHAR NALA 1'A' -1**	0.20	0.20	0.40	0.60		
	1C	**GHAGHAR NALA 1'B'**	0.75	0.75	1.50	1.80		
	1D	**DARIABAD - KATHARAGHAT DRAIN**	0.10	0.10	0.15	0.20		
	1E	**DARIABAD - PEEPALGHAT DRAIN**	0.03	0.03	0.04	0.05		
	1F	**DARIABAD - JOGIGHAT DRAIN**	0.05	0.05	0.06	0.10		
	2	**CHACHAR NALA**	34.00	34.00	41.30	52.80		
	3	**EMERGENCY OUTFALL DRAIN**	18.25	18.25	22.20	28.40		
		(through existing sewers)	8.68	8.68	8.68	0.00		
	4	**DRAIN AT GATE NO. 9**	2.00	2.00	3.00	4.00		
	5	**DRAIN AT GATE NO. 13**	4.00	4.00	5.30	7.00		
	6	**FORT DRAIN NO.1**	-	-	-	-		Under the control of Ministry of Difence & hence, discharge was not measured in 1998-1999
	6A	**FORT DRAIN NO.2**	-	-	-	-		
	7	**MORIGATE NALA including MUMFORDGANJ DRAIN**	33.94	33.94	42.40	53.70	Ganga River (Right Bank)	Near Shastri Bridge
	8	**DRAINS OF DARAGANJ AREA**	3.00	3.00	4.00	5.00	Morigate Nala	
	9	**ALENGANJ NALA**	27.10	27.10	32.90	42.00	Salori Nala	Near Buxi Bund
	10	**SALORI NALA**						Near Buxi Bund
DRAINS OF TELIYARGANJ AREA/ RASULABAD DRAINS	11	**JONDHWAL NALA**	2.50	2.50	3.10	3.90	Ganga River (Right Bank)	Teliyarganj
	11A	**SHANKARGHAT NALA**	0.20	0.20	0.21	0.31		Teliyarganj
	11B	**RASULABAD PACCAGHAT DRAIN**	0.04	0.04	0.05	0.06		Rasoolabad Ghat
	11C	**ADA COLONY NALA**	1.60	1.60	1.95	2.50		Rasoolabad Ghat
	11D	**JONDHWAL RASULABAD DRAIN (MURDAGHAT)**	0.07	0.07	0.08	0.11		Rasoolabad Ghat
	11E	**SHANKARGHAT COLONY DRAIN (near Phaphamau Bridge)**	0.01	0.01	0.01	0.02		Near Phaphamau Bridge
	11F	**JONDHWALGHAT DRAIN**	0.07	0.07	0.08	0.11		Teliarganj
	12	**RAJAPUR NALA**	7.00	7.00	8.50	10.90		Rajapur Area
	12A	**T.V. TOWER NALA**	2.00	2.00	2.45	3.10	Rajapur Nala	Rajapur Area
	12B	**SADAR BAZAR NALA**	3.00	3.00	3.65	4.70		Rajapur Area
	12C	**UNCHWAGHARI DRAIN-I**	0.70	0.70	0.85	1.10		Kachhar of Rajapur Area
	12D	**UNCHWAGHARI DRAIN-II**	0.25	0.25	0.30	0.40		Kachhar of Rajapur Area
	12E	**BELIGAON DRAIN**	0.25	0.25	0.30	0.40		Kachhar of Rajapur Area
	12F	**MUMFORDGANJ DRAIN (balance discharge)**	0.40	0.40	0.50	0.62		Kachhar of Rajapur Area
	12G	**MUIRABAD (GANESH NAGAR) NALA**	1.00	1.00	1.21	1.55		Kachhar of Rajapur Area
	12H	**NAYAPURWA DRAIN**	0.06	0.06	0.07	0.10		Kachhar of Rajapur Area
	12I	**MEHDAURI GAON DRAIN**	0.20	0.20	0.25	0.31		Kachhar of Rajapur Area
	13	**MAWAIYA NALA**	9.00	9.00	11.00	14.00	Ganga River (Right Bank)	Near Mawaiya Village (Naini Area)
	14	**SHIVKUTI DRAIN NO.1**	0.02	0.02	0.02	0.03		Near Shivkuti Temple
	14A	**SHIVKUTI DRAIN NO.2**	0.01	0.01	0.01	0.02		Near Shivkuti Temple
	14B	**SHIVKUTI DRAIN NO.3 (North)**	1.60	1.60	1.95	2.50		Near Shivkuti Temple
	14C	**SHIVKUTI DRAIN NO.4**	0.01	0.01	0.01	0.02		Near Shivkuti Temple
	14D	**SHIVKUTI DRAIN NO.5**	0.01	0.01	0.01	0.02		Near Shivkuti Temple
	14E	**SHIVKUTI DRAIN NO.6**	0.02	0.02	0.02	0.03		Near Shivkuti Temple
	14F	**SHIVKUTI DRAIN NO.7 (East)**	0.72	0.72	0.90	1.15		Near Shivkuti Temple
	15	**CHILLA DRAIN**	-	-	-	-		Absorbed in sandy Strata of river Ganga & hence, discharge was not measured in 1998-1999
	15A	**GOVINDPUR PURANI BASTI DRAIN**	-	-	-	-		
	15B	**GOVINDPUR DRAIN NO.1**	-	-	-	-		
	15C	**GOVINDPUR DRAIN NO.2**	-	-	-	-		
	15D	**GOVINDPUR DRAIN NO.3**	-	-	-	-		
	15E	**GOVINDPUR DRAIN NO.4**	-	-	-	-		
DRAINS OF PHAPHAMAU AREA	16	**CO-OPERATIVE DRAIN**	-	-	-	-	Ganga River (Left Bank)	Stagnating in a pond and does not meet river Ganga & hence, discharge was not measured in 1998-1999
	17	**BASNA DRAIN**	-	-	-	-		Carries seepage of canal water & hence, discharge was not measured in 1998-1999
	18	**INDIRA AWAS DRAIN**	0.23	0.23	0.30	0.40		Near Phaphamau Area
	19	**SHIVPUR DRAIN**	-	-	-	-		Carries seepage of canal water & hence, discharge was not measured in 1998-1999
DRAINS OF JHUSI AREA	20	**LOTEY HARAN NALA**	2.15	2.15	2.60	3.38		Jhunsi Area down stream of sangam
	21	**SHASTRI BRIDGE NALA**	0.02	0.02	0.02	0.03		Near Shastri Bridge
DRAINS OF SULEMSA RAI AREA	22	**KODARA NALA**	6.75	6.75	8.25	10.50	Ganga River (Right Bank)	Near Sulem Sarai Area
	23	**NEHRU PARK NALA**	0.50	0.50	0.60	0.80		Near Sulem Sarai Area
	24	**PONGHAT NALA**	1.75	1.75	2.15	2.75		Near Sulem Sarai Area

Table 7.2 Wastewater Generation and Nala Flow (Page 1 of 2)

Flow Balance Sheet of District A, District B, District D

Sub catchment Number	Population			Anticipated Connection Rate			Wastewater Sewered			Wastewater Unsewered			Wastewater Unsewered: Nala-wise Distribution Factor				
	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030	Ghaghar	Chachar	Morigate	Rajapur	Dis 2 Nala
A-1	18,025	26,300	40,920	40%	55%	80%	1.48	2.53	5.07	2.22	2.07	1.27	50%	50%			
A-2	7,474	11,012	17,255	40%	55%	80%	0.61	1.06	2.14	0.92	0.87	0.53		100%			
A-3	6,873	9,118	12,126	40%	55%	80%	0.56	0.88	1.50	0.85	0.72	0.38		100%			
A-4	33,164	34,129	35,035	40%	55%	80%	2.72	3.28	4.34	4.08	2.69	1.09	100%				
A-5	52,798	54,448	56,424	40%	55%	80%	4.33	5.24	7.00	6.49	4.29	1.75	30%	70%			
A-6	27,435	35,598	43,621	40%	55%	80%	2.25	3.43	5.41	3.37	2.80	1.35		100%			
A-7	7,769	8,012	8,328	40%	55%	80%	0.64	0.77	1.03	0.96	0.63	0.26		100%			
A-8	30,892	31,843	32,973	40%	55%	80%	2.53	3.06	4.09	3.80	2.51	1.02	40%	60%			
A-9	9,856	10,127	10,362	40%	55%	80%	0.81	0.97	1.28	1.21	0.80	0.32	100%				
A-10	63,331	73,006	84,916	40%	55%	80%	5.19	7.03	10.53	7.79	5.75	2.63	100%				
A-11	20,852	26,811	32,045	40%	55%	80%	1.71	2.58	3.97	2.56	2.11	0.99	100%				
A-12	16,741	17,319	17,917	40%	55%	80%	1.37	1.67	2.22	2.06	1.36	0.56	60%	40%			
A-13	41,392	51,531	61,363	40%	55%	80%	3.39	4.96	7.61	5.09	4.06	1.90	30%	70%			
A-14	37,168	43,143	50,184	40%	55%	80%	3.05	4.15	6.22	4.57	3.40	1.56		100%			
Sub Total	**373,770**	**432,397**	**503,469**				**30.64**	**41.61**	**62.41**	**45.97**	**34.06**	**15.61**					
B-1	13,356	20,277	35,407	30%	50%	80%	0.82	1.77	4.39	1.92	1.77	1.10	100%				
B-2	84,829	126,184	173,319	0%	0%	80%	0.00	0.00	21.49	17.39	22.08	5.37					50%
B-3	8,712	14,735	28,430	0%	0%	80%	0.00	0.00	3.53	1.79	2.58	0.88	50%				
FSA 2	13,099	20,337	25,332	0%	0%	80%	0.00	0.00	3.14	2.69	3.56	0.79					50%
Sub Total	**119,996**	**181,533**	**262,488**				**0.82**	**1.77**	**32.55**	**23.79**	**29.99**	**8.14**					
D-1	7,092	10,534	16,664	0%	0%	80%	0.00	0.00	2.07	1.45	1.84	0.52	100%				
D-2	11,678	16,376	24,757	0%	0%	80%	0.00	0.00	3.07	2.39	2.87	0.77			100%		
D-3	10,107	15,279	24,722	0%	0%	80%	0.00	0.00	3.07	2.07	2.67	0.77				100%	
D-4	17,814	25,254	35,038	30%	45%	80%	1.10	1.99	4.34	2.56	2.43	1.09			100%		
D-5	5,519	8,157	12,815	30%	45%	80%	0.34	0.64	1.59	0.79	0.79	0.40			100%		
D-6	2,499	3,692	5,802	30%	45%	80%	0.15	0.29	0.72	0.36	0.36	0.18			100%		
D-7	3,989	6,082	9,955	30%	45%	80%	0.25	0.48	1.23	0.57	0.59	0.31			100%		
D-8	12,764	20,089	31,269	30%	45%	80%	0.78	1.58	3.88	1.83	1.93	0.97			100%		
D-9	12,062	17,991	28,620	30%	45%	80%	0.74	1.42	3.55	1.73	1.73	0.89			100%		
D-10	21,509	25,393	31,843	30%	45%	80%	1.32	2.00	3.95	3.09	2.44	0.99			100%		
D-11	24,895	30,559	34,195	30%	45%	80%	1.53	2.41	4.24	3.57	2.94	1.06			100%		
D-12	12,990	15,403	17,672	30%	45%	80%	0.80	1.21	2.19	1.86	1.48	0.55			100%		
D-13	9,048	9,328	9,700	30%	45%	80%	0.56	0.73	1.20	1.30	0.90	0.30			100%		
D-14	37,243	40,116	44,454	30%	45%	80%	2.29	3.16	5.51	5.34	3.86	1.38			100%		
D-15	17,814	25,253	35,038	30%	45%	80%	1.10	1.99	4.34	2.56	2.43	1.09			100%		
D-16	19,898	25,405	34,592	30%	45%	80%	1.22	2.00	4.29	2.86	2.45	1.07				100%	
D-17	47,891	69,538	105,278	0%	0%	80%	0.00	0.00	13.05	9.82	12.17	3.26				100%	
Sub Total	**274,812**	**364,449**	**502,414**				**12.18**	**19.90**	**62.29**	**44.15**	**43.88**	**15.60**					
Total	**768,578**	**978,379**	**1,268,371**				**43.64**	**63.28**	**157.25**	**113.91**	**107.93**	**39.35**					
				Total Wastewater Generated			**157.55**	**171.21**	**196.60**								

Sub catchment Number	Wastewater Unsewered: Going to Ghaghar Nala			Going to Chachar Nala			Going to Morigate Nala			Going to Rajapur Nala			Going to Dist 2 Nala		
	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030
A-1	1.11	1.04	0.64	1.11	1.04	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-2	0.00	0.00	0.00	0.92	0.87	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-3	0.00	0.00	0.00	0.85	0.72	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-4	4.08	2.69	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-5	1.95	1.29	0.53	4.54	3.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-6	0.00	0.00	0.00	3.37	2.80	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-7	0.00	0.00	0.00	0.96	0.63	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-8	1.52	1.00	0.41	2.28	1.51	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-9	1.21	0.80	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-10	7.79	5.75	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-11	2.56	2.11	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-12	1.24	0.82	0.34	0.82	0.54	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-13	1.53	1.22	0.57	3.56	2.84	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-14	0.00	0.00	0.00	4.57	3.40	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub Total	**22.99**	**16.72**	**7.52**	**22.98**	**17.35**	**8.11**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
B-1	1.92	1.77	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.70	11.04	2.69
B-3	0.90	1.29	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FSA 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	1.78	0.40
Sub Total	**2.82**	**3.06**	**1.54**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**10.05**	**12.82**	**3.09**
D-1	1.45	1.84	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D-2	0.00	0.00	0.00	0.00	0.00	0.00	2.39	2.87	0.77	0.00	0.00	0.00	0.00	0.00	0.00
D-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.07	2.67	0.77	0.00	0.00	0.00
D-4	0.00	0.00	0.00	0.00	0.00	0.00	2.56	2.43	1.09	0.00	0.00	0.00	0.00	0.00	0.00
D-5	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.79	0.40	0.00	0.00	0.00	0.00	0.00	0.00
D-6	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.36	0.18	0.00	0.00	0.00	0.00	0.00	0.00
D-7	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.59	0.31	0.00	0.00	0.00	0.00	0.00	0.00
D-8	0.00	0.00	0.00	0.00	0.00	0.00	1.83	1.93	0.97	0.00	0.00	0.00	0.00	0.00	0.00
D-9	0.00	0.00	0.00	0.00	0.00	0.00	1.73	1.73	0.89	0.00	0.00	0.00	0.00	0.00	0.00
D-10	0.00	0.00	0.00	0.00	0.00	0.00	3.09	2.44	0.99	0.00	0.00	0.00	0.00	0.00	0.00
D-11	0.00	0.00	0.00	0.00	0.00	0.00	3.57	2.94	1.06	0.00	0.00	0.00	0.00	0.00	0.00
D-12	0.00	0.00	0.00	0.00	0.00	0.00	1.86	1.48	0.55	0.00	0.00	0.00	0.00	0.00	0.00
D-13	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.90	0.30	0.00	0.00	0.00	0.00	0.00	0.00
D-14	0.00	0.00	0.00	0.00	0.00	0.00	5.34	3.86	1.38	0.00	0.00	0.00	0.00	0.00	0.00
D-15	0.00	0.00	0.00	0.00	0.00	0.00	2.56	2.43	1.09	0.00	0.00	0.00	0.00	0.00	0.00
D-16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.86	2.45	1.07	0.00	0.00	0.00
D-17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.82	12.17	3.26	0.00	0.00	0.00
Sub Total	**1.45**	**1.84**	**0.52**	**0.00**	**0.00**	**0.00**	**27.95**	**24.75**	**9.98**	**14.75**	**17.29**	**5.10**	**0.00**	**0.00**	**0.00**
Total	**27.26**	**21.62**	**9.58**	**22.98**	**17.35**	**8.11**	**27.95**	**24.75**	**9.98**	**14.75**	**17.29**	**5.10**	**10.05**	**12.82**	**3.09**
After Calibration with Measured Flow	**40.00**	**31.72**	**14.06**	**34.00**	**25.67**	**12.00**	**33.94**	**30.05**	**12.12**	**14.86**	**17.42**	**5.14**	**10.05**	**12.82**	**3.09**

	District	Status	2003			2015			2030			Remarks
			Sewered	Unsewered	Total	Sewered	Unsewered	Total	Sewered	Unsewered	Total	
Naini STP	A	E	43.64	67.94	111.58	41.61	25.67	67.28	62.41	12.00	74.41	District A + Chachr Nala
Numaya Dahi STP	B	P	---	---	---	1.77	44.54	46.31	32.55	17.15	49.70	District B + Ghaghar Nala + Dist 2 Nala
Rajapur STP	D	P	---	---	---	19.90	47.47	67.37	62.29	17.26	79.55	District D + Morigate Nala+Rajapur Nala
Untreated (in 2003)			0.00	42.01	42.01	---	---	---	---	---	---	Ghaghar Nala, Rajapur Nala (in 2003)
Total			43.64	109.95	153.59	63.28	117.68	180.96	157.25	46.41	203.66	

	District	Status	2003			2015			2030			Remarks
			Sewered	Unsewered	Total	Sewered	Unsewered	Total	Sewered	Unsewered	Total	
Chachar Nala SPS	A	E		34.00	34.00		25.67	25.67		12.00	12.00	Chachar Nala
Gaughat MPS	A	E	43.64	67.94	111.58	41.61	25.67	67.28	62.41	12.00	74.41	District A + Chachr Nala SPS
Lukerganj SPS	B	E	0.82		0.82	1.77		1.77	4.39		4.39	B-1
Sasur Khaderi SPS	B	P		10.05	10.05	0.00	12.82	12.82	24.63	3.09	27.72	B-2 + FSA +Dist 2 Nala
Ghagahr Nala SPS	B	P				1.77	44.54	46.31	32.55	17.15	49.70	District B + Ghaghar Nala + Dist 2 Nala
Daraganj SPS	D	E	1.53		1.53	2.41		2.41	4.24		4.24	D-11
Allahpur SPS	D	E	2.29		2.29	3.16		3.16	5.51		5.51	D-14
Morigate Nala SPS	D	E		33.94	33.94		30.05	30.05		12.12	12.12	Morigate Nala
Alopibagh SPS	D	E	9.86	33.94	43.80	15.91	30.05	45.96	32.40	12.12	44.52	D-4 to D-14 + Morigate Nala SPS
Mumfordganj MPS	D	E	12.18	33.94	46.12	19.90	30.05	49.95	49.24	12.12	61.36	District D-1 to D-16 + Morigate Nala SPS
SPS at Rajapur STP	D	P	---	---	---		17.29	17.29		5.10	5.10	Rajapur Nala

Flow Balance Sheet of District C

Sub catchment Number	Population			Anticipated Connection Rate			Wastewater Sewered			Wastewater Unsewered			Wastewater Unsewered: Nala-wise Distribution Factor	Going to Salori Nala		
	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030	Salori	2003	2015	2030
C-1	22,059	35,316	53,549	0%	30%	80%	0.00	1.85	6.64	4.52	4.33	1.66	100%	4.52	4.33	1.66
C-2	17,024	27,572	41,937	0%	30%	80%	0.00	1.45	5.20	3.49	3.38	1.30	100%	3.49	3.38	1.30
C-3	35,318	50,592	76,376	0%	30%	80%	0.00	2.66	9.47	7.24	6.20	2.37	100%	7.24	6.20	2.37
C-4	17,678	19,819	22,867	0%	30%	80%	0.00	1.04	2.84	3.62	2.43	0.71	100%	3.62	2.43	0.71
C-5	21,105	25,415	31,215	0%	30%	80%	0.00	1.33	3.87	4.33	3.11	0.97	100%	4.33	3.11	0.97
Sub Total	**113,184**	**158,714**	**225,944**				**0.00**	**8.33**	**28.02**	**23.20**	**19.45**	**7.01**		**23.20**	**19.45**	**7.01**
				Total Wastewater Generated			**23.20**	**27.78**	**35.03**							

	District	Status	2003			2015			2030			Remarks
			Sewered	Unsewered	Total	Sewered	Unsewered	Total	Sewered	Unsewered	Total	
Salori STP	C	S	---	---	---	8.33	19.45	27.78	28.02	7.01	35.03	District C + Salori Nala
Untreated (in 2003)			0.00	23.20	23.20	---	---	---	---	---	---	Salori Nala (in 2003)
Total			0.00	23.20	23.20	8.33	19.45	27.78	28.02	7.01	35.03	

Table 7.2 Wastewater Generation and Nala Flow (Page 2 of 2)

Flow Balance Sheet of District E

Sub catchment Number	Population			Anticipated Connection Rate			Wastewater Sewered			Wastewater Unsewered		
	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030
E-1	23,026	41,994	88,970	0%	0%	50%	0.00	0.00	6.90	4.72	7.35	6.90
E-2	11,554	18,469	31,897	0%	0%	50%	0.00	0.00	2.47	2.37	3.23	2.47
E-3	15,488	24,238	40,217	0%	0%	50%	0.00	0.00	3.12	3.18	4.24	3.12
E-4	23,835	33,993	47,523	0%	0%	50%	0.00	0.00	3.68	4.89	5.95	3.68
E-5	22,955	35,125	50,265	0%	0%	50%	0.00	0.00	3.90	4.71	6.15	3.90
Sub Total	**96,858**	**153,819**	**258,872**				**0.00**	**0.00**	**20.07**	**19.87**	**26.92**	**20.07**
				Total Wastewater Generated			**19.87**	**26.92**	**40.14**			

Sub catchment Number	Wastewater Unsewered: Nala-wise Distribution Factor			Going to Ponghat Nala			Going to Kodara Nala			Going to Nehrub Park Nala		
	Ponghat	Kodara	Nehru	2003	2015	2030	2003	2015	2030	2003	2015	2030
E-1	100%			4.72	7.35	6.90	0.00	0.00	0.00	0.00	0.00	0.00
E-2		100%		0.00	0.00	0.00	2.37	3.23	2.47	0.00	0.00	0.00
E-3		100%		0.00	0.00	0.00	3.18	4.24	3.12	0.00	0.00	0.00
E-4		100%		0.00	0.00	0.00	4.89	5.95	3.68	0.00	0.00	0.00
E-5			100%	0.00	0.00	0.00	0.00	0.00	0.00	4.71	6.15	3.90
Sub Total				**4.72**	**7.35**	**6.90**	**10.44**	**13.42**	**9.27**	**4.71**	**6.15**	**3.90**

	District	Status	2003			2015			2030			Remarks
			Sewered	Unsewered	Total	Sewered	Unsewered	Total	Sewered	Unsewered	Total	
Kodara STP	E	P	---	---	---	0.00	19.57	19.57	20.07	13.17	33.24	District C + Kodara Nala + Nehru Park Nala
Ponghat STP	E	P	---	---	---	0.00	7.35	7.35	0.00	6.90	6.90	Ponghat Nala
Untreated (in 2003)			0.00	19.87	19.87							Flow of three nalas
Total			0.00	0.00	0.00	0.00	26.92	26.92	20.07	20.07	40.14	

Flow Balance Sheet of District F

Sub catchment Number	Population			Anticipated Connection Rate			Wastewater Sewered			Wastewater Unsewered		
	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030
F-1	10,153	17,591	26,865	0%	0%	50%	0.00	0.00	2.08	2.08	3.08	2.08
F-2	6,180	10,707	16,353	0%	0%	50%	0.00	0.00	1.27	1.27	1.87	1.27
F-3	4,988	8,615	13,176	0%	0%	50%	0.00	0.00	1.02	1.02	1.51	1.02
Sub Total	**21,321**	**36,913**	**56,394**				**0.00**	**0.00**	**4.37**	**4.37**	**6.46**	**4.37**
				Total Wastewater Generated			**4.37**	**6.46**	**8.74**			

Sub catchment Number	Wastewater Unsewered: Nala-wise Distribution Factor	Going to nala		
	Nala	2003	2015	2030
F-1	100%	2.08	3.08	2.08
F-2	100%	1.27	1.87	1.27
F-3	100%	1.02	1.51	1.02
Sub Total		**4.37**	**6.46**	**4.37**

	District	Status	2003			2015			2030			Remarks
			Sewered	Unsewered	Total	Sewered	Unsewered	Total	Sewered	Unsewered	Total	
Phaphamau STP	F	P	---	---	---	---	---	---	4.37	4.37	8.74	District F (including unserewed wastewater)
Untreated (in 2003, 2015)				4.37			6.46					
Total									4.37	4.37	8.74	

Flow Balance Sheet of District G

Sub catchment Number	Population			Anticipated Connection Rate			Wastewater Sewered			Wastewater Unsewered		
	2003	2015	2030	2003	2015	2030	2003	2015	2030	2003	2015	2030
G-1	10,748	18,185	33,047	0%	0%	80%	0.00	0.00	4.10	2.20	3.18	1.02
G-2	17,438	28,970	46,307	0%	0%	80%	0.00	0.00	5.74	3.57	5.07	1.44
G-3	8,281	12,485	18,677	0%	0%	80%	0.00	0.00	2.32	1.70	2.18	0.58
G-4	26,514	37,637	50,569	0%	0%	80%	0.00	0.00	6.27	5.44	6.59	1.57
FSA 1	38,283	65,325	118,389	0%	0%	80%	0.00	0.00	14.68	7.85	11.43	3.67
Sub Total	**101,264**	**162,602**	**266,989**				**0.00**	**0.00**	**33.11**	**20.76**	**28.45**	**8.28**
				Total Wastewater Generated			**20.76**	**28.45**	**41.39**			

Sub catchment Number	Wastewater Unsewered: Nala-wise Distribution Factor	Going to nala		
	Nala	2003	2015	2030
G-1	100%	2.20	3.18	1.02
G-2	100%			
G-3	100%			
G-4	100%	5.44	6.59	1.57
FSA 1	100%	7.85	11.43	3.67
Sub Total		**15.49**	**21.20**	**6.26**

	District	Status	2003			2015			2030			Remarks
			Sewered	Unsewered	Total	Sewered	Unsewered	Total	Sewered	Unsewered	Total	
Mawaiya STP	G	P	---	---	---	---	---	---	33.11	8.28	41.39	District G (including unserewed wastewater)
Untreated (in 2003, 2015)				20.76			28.45					
Total									33.11	8.28	41.39	

District B Population, Revised in Dec 09

	Area (ha)	Density			Population			
		2003	2015	2030	2003	2015	2030	
B-1	143	93.4	141.8	247.6	13,356	20,277	35,407	
B-2					84,829	126,184	173,319	blance
B-3	165	52.8	89.3	172.3	8,712	14,735	28,430	
FSA2					13,099	20,337	25,332	unchanged
Total					119,996	181,533	262,488	unchanged

Table 7.3 Existing Trunk Sewers: Hydraulic Capacity Analysis

(1) District A

Node		Node (MP1995)		Status	Design Flow (lps)		Existing sewer		Status		Proposals								Phisical Condition	Remarks
From	To	From	To		2015	2030	Diameter (mm)	Capacity (lps)	2015	2030	Size (mm)	Length (m)	Gradient	Invert level (m) u/s	Invert level (m) d/s	Ground level (m) u/s	Ground level (m) d/s	Discharge (lps)		
1	2	II-(43)	II-(44)	E	118	183	457.2	139	Adequate	NG	700	1,450	1000	93.82	92.37	96.50	96.20	246		Replace
2	2'	II-(44)	II-(45)	E	168	234	457.2	174	Adequate	NG	700	1,050	1000	89.77	85.42	96.20	88.20	246		Replace
2'	3	II-(45)	Rwy cross	E	168	234	609.6	290	Adequate	Adequate	610	600	448	84.39	83.05	88.20	88.00	290		Use Existing Pipe
3	7	Rwy cross	I-(56)	E	208	284	609.6	403	Adequate	Adequate	610	700	232	83.05	80.02	88.00	86.70	403		Use Existing Pipe
4	5	I-(33)	I-(38)	P	153	158					600	1,650	900	92.62	90.79	95.40	94.80	172		Propose
5	7	I-(38)	I-(56)	P	358	369					900	1,300	1500	85.46	83.70	94.80	86.70	392		Propose
6	7	I-(57)	I-(56)	E	160	195	1143.0	909	Adequate	Adequate	1143	1,500	1301	81.12	80.06	85.00	86.70	909	Poor	Replace
7	Gaughat PS	I-(56)	I-(58)	E	720	862	1143.0	613	NG	NG	1400	800	2200	80.00	79.64	86.70	88.20	1,052		Replace
8	Gaughat PS	I-(48)	I-(57)	P	143	148					600	1,700	900	85.54	83.65	90.00	88.20	172		Propose
9	10	I-(4)	I-(5)	E	54	57	558.8	238	Adequate	Adequate	22"x33"	750	418	90.96	88.87	92.20	92.20	238		Use Existing Pipe
10	12	I-(5)	I-(18)	E	335	385	558.8	202	NG	NG	900	400	1500	88.31	88.04	92.20	93.00	392	Poor	Replace
11	12	I-(14)	I-(18)	E	120	143	1372.0	4,112	Adequate	Adequate	1372	750	168	88.18	85.06	91.70	93.00	4,112		Use Existing Pipe
12	13	I-(18)	I-(26)	E	513	587	558.8	285	Adequate	Adequate	22"x33"	1,050	291	88.18	83.26	93.00	86.10	285	Poor	Replace
				E			1372.0	2,258			1372	1,050	558	85.06	83.04			2,258		
							Total	2,543										2,543		
13	Gaughat PS	I-(26)	I-(27)	E	722	835	558.8	329	Adequate	Adequate	22"x33"	850	219	83.26	79.30	86.10	88.20	329	Poor	Replace
				E			1372.0	2,360			1372	850	511	83.04	81.35			2,360		
							Total	2,689										2,689		
14	Gaughat PS	I-(51)	I-(52)	E	193	203	609.6	418	Adequate	Adequate	610	1,350	216	84.88	79.78	86.00	88.20	418		Use Existing Pipe
Gaughat PS	Naini STP			E	1,746	2,032	914.4		Adequate	Adequate		Rising Main								Use Existing Pipe
				E			685.8													

Capacity of existing sewers: Calculated based on diameter and invert level discribed on long-section drawings of existing sewers of Master Plan formulated in 1995

(2) District D (Page 1 of 2)

Node		Node (MP1995)		Status	Design Flow (lps)		Existing sewer		Status		Proposals								Remarks
From	To	From	To		2015	2030	Diameter (mm)	Capacity (lps)	2015	2030	Size (mm)	Length (m)	Gradient	Invert level (m) u/s	Invert level (m) d/s	Ground level (m) u/s	Ground level (m) d/s	Discharge (l/s)	
Gravuity Sewer Area																			
1	2			P	48	90					500	1,600	700	93.62	91.33	96.20	94.80	120	Propose
2	4	II-(4)	II-(3)	P	123	185					700	850	1,000	91.13	89.12	94.80	91.90	246	Propose
3	4	II-(101)	II-(3)	P	70	110					500	2,300	700	92.32	89.32	94.90	91.90	120	Propose
4	Mumfort PS(18)	II-(53)	II-(5)	P	192	268					800	1,100	1,000	89.01	87.11	91.90	90.00	351	Propose
Pumping Area																			
5	8	II-(16)	II-(18)	E	115	158	889.0	2,057	Adequate	Adequate	35"x53"	750				94.00	87.40	2,057	Use Existing Pipe
6	7	II-(10)	II-(12)	P	37	69					500	1,100	700	90.39	88.82	95.30	91.40	120	Propose
7	8	II-(12)	II-(18)	E	54	99	457.2	97	NG	NG	500	1,200	700	88.82	84.82	91.40	87.40	120	Replace
8	11	II-(18)	II-(25)	E	197	257	889.0	1,048	Adequate	Adequate	35"x53"	950				87.40	84.00	1,048	Use Existing Pipe
																			Use Existing Pipe
9	11	II-(19)	II-(21)	E	92	140	508.0	86	NG	NG	600	1,500	900	87.32	80.20	90.00	84.00	172	Replace
		II-(21)	II-(22)	E				no data											
10	11	II-(24)	II-(25)	E	82	128	609.6	288	Adequate	Adequate	610	1,500				92.00	84.00	288	Use Existing Pipe
11	Alopibagh PS(16)	II-(25)	II-(26)	E	486	628	990.6	1,288	Adequate	Adequate	39"x57"	700				84.00	83.60	1,288	Use Existing Pipe
Daraganj PS(12)	13	II-(36)	II-(38)	E	139	153					400	700	Rising Main						
13	15	II-(38)	II-(39)	E	209	209	457.2	103	NG	NG	700	400	1,000	81.22	80.82	84.00	83.60	246	Replace
Allahpur PS(14)	15	II-(32)	II-(38)	E	183	200	355.6	Rising Main								83.00	83.60		Replace
15	Alopibagh PS(16)	II-(39)	II-(41)	E	435	428	321.6	222	NG	NG	1000	900	1,500	80.50	79.90	83.60	83.60	520	Replace
		II-(41)	II-(42)				451.4	304	NG	NG									Replace
Alopibagh PS(16)	17			P	921	1,055					1000	2,500	Rising Main	81.00	91.40	83.60	94.00		Propose
17	Mumford PS(18)			P	1,036	1,197					1600	2,000	2,500	90.26	85.94	94.00	90.00	1,409	Propose
Mumford PS(18)	Rajapur STP(20)			P	1,344	1,602					1800	1,500	2,500	85.74	81.05	90.00	85.00	1,928	Propose

(2) District D (Page 2 of 2)

Node		Node (MP1995)		Status	Design Flow (lps)		Existing sewer		Status		Proposals								Remarks
														Invert level (m)		Ground level (m)			
From	To	From	To		2015	2030	Diameter (mm)	Capacity (lps)	2015	2030	Size (mm)	Length (m)	Gradient	u/s	d/s	u/s	d/s	Discharge (l/s)	
Area along Nala																			
19	Rajapur STP(20)			P	317	425	-				1000	2,000	1,500	87.90	81.90	91.00	85.00	520	Propose

Capacity of existing sewer: Adopting calculated values on Table 7.2.1 of Master Plan in 1995

Table 7.4 Proposed Trunk Sewers: Hydraulic Calculation (Year of 2030)

(1) District A

Node		Contributory Population		Design Flow (lps)	Size (mm)	Length (m)	Gradient	Invert level (m)		Ground level (m)		Covering (m)		Full pipe capacity		Design capacity			Remarks
From	To	Each	Cumulative					u/s	d/s	u/s	d/s	u/s	d/s	Velocity (m/s)	Discharge (l/s)	Depth ratio d/df	Velocity (m/s)	Discharge (l/s)	
1	2	40,920	40,920	183	700	2,200	1000	93.22	91.02	96.00	96.20	2.00	4.40	0.66	254	0.80	0.752	246	Replace
2	3	17,255	58,175	234	700	1,650	1000	91.02	85.22	96.20	88.00	4.40	2.00	0.66	254	0.80	0.752	246	Replace
3	7	12,126	70,301	284	610	700	232	83.05	80.02	88.00	86.70	4.26	5.99	1.25	366	0.80	1.426	354	
4	5	35,035	35,035	158	600	900	900	92.72	91.72	95.40	94.80	2.00	2.40	0.63	178	0.80	0.716	172	New
5	7	56,424	91,459	369	900	1,250	1500	91.42	83.70	94.80	86.70	2.38	2.00	0.64	405	0.80	0.726	392	New
6	7	43,621	43,621	195	700	1,500	1000	82.22	80.72	85.00	86.70	2.00	5.20	0.66	254	0.80	0.752	246	Replace
7	Gaughat SPS(15)	8,328	213,709	862	1400	800	2200	80.02	79.66	86.70	88.20	5.15	7.01	0.71	1087	0.80	0.805	1,052	Replace
8	Gaughat SPS(15)	32,973	32,973	148	600	1,200	900	85.54	84.21	90.00	88.20	3.78	3.31	0.63	178	0.80	0.716	172	New
9	10	10,362	10,362	57	559	300	418	90.96	88.87	92.20	92.20	0.60	2.69	0.88	216	0.80	1.002	209	
10	12	84,916	95,278	385	900	750	1500	88.47	87.97	92.20	93.00	2.73	4.03	0.64	405	0.80	0.726	392	
11	12	32,045	32,045	143	600	1,100	900	87.52	86.30	90.20	93.00	2.00	6.02	0.63	178	0.80	0.716	172	
12	13	17,917	145,240	587	1200	1,050	2000	85.70	82.78	93.00	86.10	5.99	2.00	0.67	757	0.80	0.763	733	Replace
13	Gaughat SPS(15)	61,363	206,603	835	1400	850	2200	82.56	82.17	86.10	88.20	2.00	4.50	0.71	1087	0.80	0.805	1,052	Replace
14	Gaughat SPS(15)	50,184	50,184	203	610	1,350	216	84.88	79.78	86.00	88.20	0.43	7.73	1.30	379	0.80	1.477	367	
Gaughat SPS(15)	Naini STP(16)		503,469	2,032	914 686	1,500	Rising Main			88.20	84.00								

(2) District B

Node		Contributory Population		Design Flow (lps)	Size (mm)	Length (m)	Gradient	Invert level (m)		Ground level (m)		Covering (m)		Full pipe capacity		Design capacity			Remarks
From	To	Each	Cumulative					u/s	d/s	u/s	d/s	u/s	d/s	Velocity (m/s)	Discharge (l/s)	Depth ratio d/df	Velocity (m/s)	Discharge (l/s)	
Lukarganj SPS(1)	3	147,523	147,523	596	1200	1,300	2000	92.09	86.69	95.40	90.00	2.00	2.00	0.67	757	0.80	0.763	733	
2	3	25,332	25,332	113	500	2,000	700	90.42	87.42	93.00	90.00	2.00	2.00	0.63	124	0.80	0.719	120	
3	Ghaghar SPS(4)	44,817	217,672	878	1400	2,000	2200	86.47	84.47	90.00	88.00	2.00	2.00	0.71	1087	0.80	0.805	1,052	
Ghaghar SPS(4)	Numaya STP(5)	44,817	262,488	1,060	1000	10,000	Rising Main			88.00		1.50	1.50	1.35					Rising Main

(3) District C

Node		Contributory Population		Design Flow (lps)	Size (mm)	Length (m)	Gradient	Invert level (m)		Ground level (m)		Covering (m)		Full pipe capacity		Design capacity			Remarks
From	To	Each	Cumulative					u/s	d/s	u/s	d/s	u/s	d/s	Velocity (m/s)	Discharge (l/s)	Depth ratio d/df	Velocity (m/s)	Discharge (l/s)	
1	2	53,549	53,549	216	700	600	1000	88.22	87.12	92.00	91.50	3.00	3.60	0.66	254	0.80	0.752	246	
2	3	41,937	95,486	385	900	750	1500	85.50	85.00	91.50	88.30	5.00	2.30	0.64	405	0.80	0.726	392	
3	4	76,376	171,862	693	1200	2,000	2000	84.70	83.70	88.30	88.60	2.28	3.58	0.67	757	0.80	0.763	733	
4	5	22,867	194,729	785	1400	2,600	2200	83.50	82.32	88.60	90.00	3.56	6.15	0.71	1087	0.80	0.805	1,052	
5	Salori STP(7)	31,215	225,944	911	1400	2,000	2200	82.32	78.47	90.00	82.00	6.15	2.00	0.71	1087	0.80	0.805	1,052	

(4) District D (Page 1 of 2)

Node		Contributory Population		Design Flow (lps)	Size (mm)	Length (m)	Gradient	Invert level (m)		Ground level (m)		Covering (m)		Full pipe capacity		Design capacity			Remarks
From	To	Each	Cumulative					u/s	d/s	u/s	d/s	u/s	d/s	Velocity (m/s)	Discharge (l/s)	Depth ratio d/df	Velocity (m/s)	Discharge (l/s)	
Gravity Sewer Area																			
1	2	16,664	16,664	90	500	1,600	700	93.62	91.33	96.20	94.80	2.00	2.89	0.63	124	0.80	0.719	120	New
2	4	24,757	41,421	185	700	850	1000	91.13	89.12	94.80	91.90	2.89	2.00	0.66	254	0.80	0.752	246	New
3	4	24,722	24,722	110	500	2,000	700	92.32	89.32	94.90	91.90	2.00	2.00	0.63	124	0.80	0.719	120	New
4	18	0	66,143	268	800	1,100	1000	89.01	87.11	91.90	90.00	2.00	2.00	0.72	363	0.80	0.823	351	New
Pumping Area																			
5	8	35,038	35,038	158	889	850				94.00	87.40							2,057	
6	7	12,815	12,815	69	500	1,100	700	90.39	88.82	95.30	91.40	4.33	2.00	0.63	124	0.80	0.719	120	New
7	8	5,802	18,617	99	500	1,200	700	88.82	84.82	91.40	87.40	2.00	2.00	0.63	124	0.80	0.719	120	Replace
8	11	9,955	63,610	257	889	950				87.40	84.00							1,048	
9	11	31,269	31,269	140	600	1,500	900	87.32	80.20	90.00	84.00	2.00	3.12	0.63	178	0.80	0.716	172	Replace
10	11	28,620	28,620	128	610	1,500				92.00	84.00							288	
11	Alopibagh SPS(16)	31,843	155,342	628	991	700				84.00	83.60							1,288	
Daraganj SPS(12)	13	34,195	34,195	153	305	700	Rising Main			88.00	84.00	1.50	1.50	2.09					
13	15	17,672	51,867	209	700	400	1000	81.22	80.82	84.00	83.60	2.00	2.00	0.66	254	0.80	0.752	246	Replace
Allahpur SPS(14)	15	44,454	44,454	200	356	250	Rising Main			83.00	83.60	1.50	1.50	2.01					
15	Alopibagh SPS(16)	9,700	106,021	428	1000	900	1500	80.50	79.90	83.60	83.60	2.00	2.60	0.68	537	0.80	0.780	520	Replace
Morigate SPS	Alopibagh SPS(16)			573	500/700	1,950	Rising Main					1.50	1.50						Existing/New
Alopibagh SPS(16)	17		261,363	1,055	1000	2,500	Rising Main			83.60	94.00	1.50	1.50	1.34					New

(4) District D (Page 2 of 2)

Node		Contributory Population		Design Flow (lps)	Size (mm)	Length (m)	Gradient	Invert level (m)		Ground level (m)		Covering (m)		Full pipe capacity		Design capacity			Remarks
From	To	Each	Cumulative					u/s	d/s	u/s	d/s	u/s	d/s	Velocity (m/s)	Discharge (l/s)	Depth ratio d/df	Velocity (m/s)	Discharge (l/s)	
17	Mumford SPS(18)	35,038	296,401	1,197	1600	2,000	2500	89.66	85.94	94.00	90.00	2.60	2.32	0.72	1,456	0.80	0.825	1,409	New
Mumford SPS(18)	Rajapur STP(20)	34,592	397,136	1,602	1000	2,000	Risin Main			90.00	85.00	1.50	1.50	2.04		0.80	2.326		New
Area along Nala																			
19	Rajapur STP(20)	105,278	105,278	425	1000	2,000	1500	87.90	81.90	91.00	85.00	2.00	2.00	0.68	537	0.80	0.780	520	New

(5) District E

Node		Contributory Population		Design Flow (lps)	Size (mm)	Length (m)	Gradient	Invert level (m)		Ground level (m)		Covering (m)		Full pipe capacity		Design capacity			Remarks
From	To	Each	Cumulative					u/s	d/s	u/s	d/s	u/s	d/s	Velocity (m/s)	Discharge (l/s)	Depth ratio d/df	Velocity (m/s)	Discharge (l/s)	
1	2	88,970	88,970	360	900	2,400	1500	93.36	91.76	98.00	96.10	3.64	3.34	0.64	405	0.80	0.726	392	
2	Kodara STP(6)	31,897	120,867	488	1000	2,000	1500	87.33	86.00	96.10	90.00	7.67	2.90	0.68	537	0.80	0.780	520	
3	5	87,740	87,740	353	900	1,650	1500	93.00	90.00	96.00	93.00	2.00	2.00	0.64	405	0.80	0.726	392	
4	5	50,265	50,265	203	700	2,250	1000	90.62	88.37	94.30	93.00	2.90	3.85	0.66	254	0.80	0.752	246	
5	Kodara STP(6)	0	138,005	558	1200	1,000	2000	87.18	86.68	94.00	90.00	5.50	2.00	0.67	757	0.80	0.763	733	

(6) District F

Node		Contributory Population		Design Flow (lps)	Size (mm)	Length (m)	Gradient	Invert level (m)		Ground level (m)		Covering (m)		Full pipe capacity		Design capacity			Remarks
From	To	Each	Cumulative					u/s	d/s	u/s	d/s	u/s	d/s	Velocity (m/s)	Discharge (l/s)	Depth ratio d/df	Velocity (m/s)	Discharge (l/s)	
1	3	26,865	26,865	120	500	1,850	700	89.76	87.12	94.50	89.70	4.16	2.00	0.63	124	0.80	0.719	120	
2	3	16,353	16,353	87	500	1,300	700	88.32	86.46	90.90	89.70	2.00	2.66	0.63	124	0.80	0.719	120	
3	Phaphamau	13,176	56,394	227	700	500	1000	86.26	85.76	89.70	90.00	2.66	3.46	0.66	254	0.80	0.752	246	

(7) District G

Node		Contributory Population		Design Flow (lps)	Size (mm)	Length (m)	Gradient	Invert level (m)		Ground level (m)		Covering (m)		Full pipe capacity		Design capacity			Remarks
From	To	Each	Cumulative					u/s	d/s	u/s	d/s	u/s	d/s	Velocity (m/s)	Discharge (l/s)	Depth ratio d/df	Velocity (m/s)	Discharge (l/s)	
1	2	33,047	33,047	148	600	900	900	83.62	82.62	86.30	86.00	2.00	2.70	0.63	178	0.80	0.716	172	
2	4	46,307	79,354	320	800	800	1000	82.42	81.62	86.00	90.00	2.69	7.49	0.72	363	0.80	0.823	351	
3	4	77,872	77,872	315	800	1,100	1000	87.11	86.01	90.00	90.00	2.00	3.10	0.72	363	0.80	0.823	351	
4	5	50,569	207,795	839	1400	400	2200	81.02	80.84	90.00	90.00	7.44	7.63	0.71	1087	0.80	0.805	1,052	
5	Mawaiya STP	59,195	266,989	1,078	1600	1,200	2500	80.64	80.16	90.00	88.00	7.62	6.10	0.72	1456	0.80	0.825	1,409	

Table 7.6 Pumping Station Inventory

	District	Status	Exisiting pumps				Year of installation/	Allowable discharge (1)	Sump capacity	Exisiting rising mains	
			No.	lpm	lps	Head (m)	renovation	lps	m3	dia (inch)	Length (m)
Chachar Nala SPS	A	E	3	18,000	300	17		677	65	600mm	450
			2	3,470	58					450mm	450
Gaughat SPS	A	E	5	37,000	617	35	1988	1,852	185	1 x 27	
					-					1 x 36	
Lukerganj SPS	B	E	3	6,300	105	7	1964	258	44.5	400	840
			2	2,130	36	7					
Daraganj SPS	D	E	3	1,500	25	22	1988	63	25.83	12	200
			2	600	10	22					
Allahpur SPS	D	E	3	6,000	100	20	1988	253	41	14	220
			2	2,400	40	20					
Morigate Nala SPS	D	E	2	8,400	140	12		233	n.a.	500	1950
			1	4,200	70	12					
Alopibagh SPS	D	E	4	11,300	188	9	1964	1,069	17	900mm	3600
			3	17,000	283	10	1988				
Mumfordganj SPS	D	E	2	6,800	113	27		158	220.5	20	2550
			2	1,350	23	15					

(1) Source: Master Plan 1995, assuming 50% additional capacity

Table 7.7 Pump Station Design Capacities (Page 1 of 3)

Pump stations	District	Existing/ Proposed Allowable at 50% (lps)	Design Discharge (lps)											
			2003				2015				2030			
			Status	pk	avg	npk	Status	pk	avg	npk	Status	pk	avg	npk
Chachar Nala SPS	A	677	**inadequate**	**787**	394	197	adequate	594	297	149	adequate	278	139	69
Gaughat MPS	A	1,852	**inadequate**	**1,883**	941	471	adequate	1,557	779	389	adequate	1,722	861	431
Lukerganj SPS	B	258	adequate	104	52	26	adequate	217	108	54	**inadequate**	**423**	212	106
Ghaghar Nala SPS	B	1,634	Proposed				adequate	1,075	538	269	adequate	1,090	545	272
Daraganj SPS	D	63	adequate	35	18	9	adequate	56	28	14	**inadequate**	**98**	49	25
Allahpur SPS	D	253	adequate	53	27	13	adequate	73	37	18	adequate	128	64	32
Morigate Nala SPS	D	233	**inadequate**	**786**	393	196	**inadequate**	**696**	348	174	**inadequate**	**281**	140	70
Alopibagh SPS	D	1,069	adequate	1,014	507	253	adequate	1,064	532	266	adequate	1,031	515	258
Mumfordganj SPS	D	158	**inadequate**	**1,068**	534	267	**inadequate**	**1,156**	578	289	**inadequate**	**1,420**	710	355

Peak (pk)	2
Average (avg)	1
Non-peak (npk)	0.5

Table 7.7 Pump Station Design Capacities (Page2 of 3)

	Exisiting pumps				Proposed pumps										Proposed rising main		
	Installed				2015					2030					head	dia.	length
					Pk flow	Req'd capacity	Installed pump capacity			Pk flow	Req'd capacity	Installed pump capacity					
	No.	lpm	lps	Total lps	(lps)	Pk flow * 1.5	Total	No.	lps	(lps)	Pk flow * 1.5	Total	No.	lps	(m)	mm	m
Chachar Nala SPS	3	18,000	300	1,016	594	891	1,016	3	300	278	417	1,016	3	300	17	exisiting	450
	2	3,470	58			-		2	58		-		2	58			
Gaughat MPS	5	37,000	617	3,083	1,557	2,336	3,085	5	617	1,722	2,584	3,085	5	617		existing	
			-														
Lukerganj SPS	3	6,300	105	386	217	325	387	3	105	423	635	660	4	120	15	700	30
	2	2,130	36					2	36				3	60			
Ghaghar Nala MPS	6	15,600	260	2,360	1,075	1,613	1,640	6	180	1,090	1,634	1,640	6	180		1,200	10,000
	4	12,000	200					4	140				4	140			
Daraganj SPS	3	1,500	25	95	56	84	95	3	25	98	147	155	5	25	10	existing	200
	2	600	10					2	10				3	10			
Allahpur SPS	3	6,000	100	380	73	110	380	3	100	128	191	380	3	100	20	exisiting	220
	2	2,400	40					2	40				2	40			
Morigate Nala SPS	2	8,400	140	350	696	1,043	1,080	6	120	281	421	1,080	6	120	18	1,000	1,950
	1	4,200	70					4	90				4	90			
Alopibagh SPS	4	11,300	188	1,603	1,064	1,596	1,603	4	188	1,031	1,546	1,603	4	188	15	1,000	2,500
	3	17,000	283					3	283				3	283			
Mumfordganj MPS	2	6,800	113	272	1,156	1,734	1,760	6	200	1,420	2,131	2,160	6	240	13	1,000	2,000
	2	1,350	23					4	140				4	180			

Table 7.7 Pump Sation Design Capacities (Page 3 of 3)

	Peak flows (lps)			Exisiting sump	Exisiting Sump Holding Time			Design Holding Time	Required Sump Capacity			Extra sump capacity required in 2030
	2003	2015	2030	m3	2003	2015	2030	(min)	2003	2015	2030	m3
Chachar Nala SPS	787	594	278	65	1.38	1.82	3.90	5.0	236	178	83	113
Gaughat MPS	1,883	1,557	1,722	185	1.64	1.98	1.79	5.0	565	467	517	332
Lukerganj SPS	104	217	423	45	7.10	3.42	1.75	5.0	31	65	127	83
Ghaghar Nala MPS	P	1,075	1,090					5.0		323	327	327
Daraganj SPS	35	56	98	26	12.16	7.72	4.39	5.0	11	17	29	4
Allahpur SPS	53	73	128	41	12.89	9.34	5.36	5.0	16	22	38	acceptable
Morigate Nala SPS	P	696	281					5.0		209	84	84
Alopibagh SPS	1,014	1,064	1,031	17	0.28	0.27	0.27	5.0	304	319	309	292
Mumfordganj MPS	1,068	1,156	1,420	221	3.44	3.18	2.59		320	347	426	206

Table 7.8 Ghaghar Nala PS (Page 1 of 2)

Average flow 47 mld Year: 2030

Pumpin hours

	Condition	Flow factor	Hours	Total flow	no. of pumps	Calculated discharge	Proposed discharge	actual hours of pumping
				m3		lps	lps	
1	peak	2	4	15667	6	190	260	2.79
2	Average	1	12	23500	4	140	200	8.16
3	non-peak	0.5	8	7833	2	140	200	5.44
			24	47000				16.39

Length of rising main	10000	m	
Friction factor C	110		Hf = 10.7 Q1.85L / C1.85 D4.87
minor losses	10%		minor losses = 10%
Static head	12.0	m	assume PSC pipe
Peak flow	1.56	m3/s	
Average flow	0.80	m3/s	
non-peak flow	0.40	m3/s	

	Dia of rising main	flow condition	Head loss in rising main	Velocity	minor losses	static head	total head
	mm		m	m/s	m	m	m
1	900	peak	68.07	2.45	6.81	12.00	86.87
	900	average	19.79	1.26	1.98	12.00	33.76
	900	non-peak	5.49	0.63	0.55	12.00	18.04
2	1000	peak	40.75	1.99	4.07	12.00	56.82
	1000	average	11.84	1.02	1.18	12.00	25.03
	1000	non-peak	3.29	0.51	0.33	12.00	15.61
3	1200	peak	16.77	1.38	1.68	12.00	30.44
	1200	average	4.87	0.71	0.49	12.00	17.36
	1200	non-peak	1.35	0.35	0.14	12.00	13.49
4	1400	peak	7.91	1.01	0.79	12.00	20.71
	1400	average	2.30	0.52	0.23	12.00	14.53
	1400	non-peak	0.64	0.26	0.06	12.00	12.70

Table 7.8 Ghaghar Nala PS (Page 2 of 2)

Pump efficiency	0.82	
Motor efficiency	0.91	
Cost of electricity	3.1	Rs/kwH

	Dia of rising main	flow condition	Actual pumping hours	Total head	Flow	Power required by each pump	Power required by motor	Total power consummed per day	Daily energy cost	Annual Energy Cost
	mm			m	m3/s	kw	kw	kwh	Rs	Rs
1	900	peak	2.79	86.87	1.56	270.21	296.94	4,970	2,666	
	900	average	8.16	33.76	0.80	80.79	88.78	2,898	2,104	
	900	non-peak	5.44	18.04	0.40	43.16	47.43	516	526	
									5,296	9,486,207
2	1000	peak	2.79	56.82	1.56	176.74	194.22	3,251	1,637	
	1000	average	8.16	25.03	0.80	59.89	65.81	2,148	1,676	
	1000	non-peak	5.44	15.61	0.40	37.36	41.05	447	487	
									3,800	6,614,137
3	1200	peak	2.79	30.44	1.56	94.70	104.06	1,742	1,095	
	1200	average	8.16	17.36	0.80	41.54	45.65	1,490	1,450	
	1200	non-peak	5.44	13.49	0.40	32.27	35.46	386	466	
									3,011	4,093,274
4	1400	peak	2.79	20.71	1.56	64.41	70.78	1,185	1,018	
	1400	average	8.16	14.53	0.80	34.77	38.21	1,247	1,418	
	1400	non-peak	5.44	12.70	0.40	30.39	33.40	363	463	
									2,898	3,162,570

P=9.8*Head*Q/Eff.

Length of rising main

Length of rising main	0	m
Pump cost	36000	Rs/Kw
Pump design period	15	years
Pipeline Design period	30	years
Pipeline Maintenance cost	0.25%	
Pump Maintenance cost	3%	
Capital discount factor	5%	

	Diameter	Cost of pumps	Cost of Pipe total	Annual recurring cost: Pipeline maintenance	Annual recurring cost: Pump maintenance	Annual recurring cost: Energy charges	Total	Present Value of annual recurring cost	Total Cost
	mm								
1	900	80,337,588	115,832,867	289,582	2,410,128	9,486,207	12,185,916	126,485,646	242,318,513
2	1000	54,384,178	127,273,952	318,185	1,631,525	6,614,137	8,563,847	88,889,803	216,163,755
3	1200	31,604,448	171,562,123	428,905	948,133	4,093,274	5,470,313	56,779,979	228,342,102
4	1400	23,194,151	209,157,347	522,893	695,825	3,162,570	4,381,288	45,476,266	254,633,613

assume PSC pipe

select 800mm rising main as most economical diameter

Table 7.11 Naini STP - Average Monthly Infolw and Effluent Characteristics

Month	Flow	BOD(mg/l)		SS(mg/l)		MPN		Removal rate(%)		
	(MLD)	in	eff	in	eff	in	eff	BOD	SS	MPN
Jan-02	60.48	130	31	375	43	7.07E+07	1.34E+07	76.15	88.53	81.05
Feb-02	63.99	153	33	400	43	1.21E+08	1.62E+06	78.43	89.25	98.66
Mar-02	59.42(*1	150.	31	379	42	1.43E+08	1.11E+07	79.33	88.92	92.24
Apr-02	56.54(*1	131	32	375	44	1.26E+08	8.28E+06	75.57	88.27	93.43
May-02	52.84(*1	128	31	378	42	1.43E+08	1.78E+06	75.78	88.89	98.76
Jun-02	59.42(*2	131	31	354	42	1.60E+08	1.47E+07	76.34	88.14	90.81
Jul-02	59.42(*2	138	32	383	44	1.37E+08	1.91E+07	76.81	88.51	86.06
Aug-02	59.42(*2			375	40	7.60E+07	1.04E+07		89.33	86.32
Sep-02	59.42(*2	142	29	377	40	1.29E+08	1.68E+06	79.58	89.39	98.70
Oct-02	59.42(*2	132	29	385	42	1.43E+08	1.11E+07	78.03	89.09	92.24
Nov-02	64.24	150	30	380	42	1.43E+08	1.46E+07	80.00	88.95	89.79
Dec-02	59.11	139	30	386	41	9.33E+07	4.93E+06	78.42	89.38	94.72
Jan-03	72.96	140	33	383	44	7.30E+07	1.02E+07	76.43	88.51	86.03
Feb-03	70.00	137	30	386	43	1.18E+08	1.39E+07	78.10	88.86	88.22
Mar-03	73.32	143	31	381	43	1.15E+08	1.08E+07	78.32	88.71	90.61
AVG *3	66.30	142	31	384	43	1.05E+08	9.92E+06	77.98	88.88	89.87

Note;*1 Due to power cut from 10:00-14:00 the water production in the city has been effected which in turn has reduced the sewage generation.

Note;*2 During rainy season i.e. from 15/6/2002 to 15/10/2002 the outlet gates of Mori gate nala, chachar Nala & Mumfordganj Nala are opened & waste water finds its way to river Ganga/Yamuna.Hence lesser quantity of waste water reaches to STP.

Note;*3 Average value is given by omitting the data during Mar-02. - Oct-02.

Table 7.13 Alopibagh PS (Page1 of 2)

Average flow 45.0 mld — Allopibagh 2030

	Condition	Flow factor	Hours	Total flow	no. of pumps	Calculated discharge	Proposed discharge	actual hours of pumping
				m3		lps	lps	
1	peak	2	4	15,000	3	350	283	4.02
								3 pumps @ 283 lps + 1 @ 188 lps
2	Average	1	12	22,500	4	140	188	8.31
3	non-peak	0.5	8	7,500	2	140	188	5.54
			24	45,000				17.87

Length of rising main	2500	m
Friction factor C	110	
minor losses	10%	
Static head	10.0	m
Peak flow	0.849	m3/s
Average flow	0.752	m3/s
non-peak flow	0.376	m3/s

	Dia of rising main	flow condition	Head loss in rising main	Velocity	minor losses	static head	total head
	mm		m	m/s	m	m	m
1	900	peak	5.52	1.33	0.55	10.00	16.07
	900	average	4.41	1.18	0.44	10.00	14.85
	900	non-peak	1.22	0.59	0.12	10.00	11.35
2	1000	peak	3.31	1.08	0.33	10.00	13.64
	1000	average	2.64	0.96	0.26	10.00	12.90
	1000	non-peak	0.73	0.48	0.07	10.00	10.81
3	1100	peak	2.08	0.89	0.21	10.00	12.29
	1100	average	1.66	0.79	0.17	10.00	11.83
	1100	non-peak	0.46	0.40	0.05	10.00	10.51
4	1200	peak	1.36	0.75	0.14	10.00	11.50
	1200	average	1.09	0.66	0.11	10.00	11.20
	1200	non-peak	0.30	0.33	0.03	10.00	10.33

Hf = 10.7 Q1.85L / C1.85 D4.87
minor losses = 10%
assume PSC pipe

Table 7.13 Alopibagh PS (page2 of 2)

Pump efficiency 0.82
Motor efficiency 0.91
Cost of electricity 3.1 Rs/kwH

	Dia of rising main	flow condition	Actual pumping hours	Total head	Flow	Power required by each pump	Power required by motor	Total power consummed per day	Daily energy cost	Annual Energy Cost
	mm			m	m3/s	kw	kw	kwh	Rs	Rs
1	900	peak	4.02	16.07	0.85	54.42	59.80	721	2,235	
	900	average	8.31	14.85	0.75	33.41	36.71	1,220	3,783	
	900	non-peak	5.54	11.35	0.38	25.52	28.04	311	963	
									6,981	2,548,141
2	1000	peak	4.02	13.64	0.85	46.17	50.73	612	1,896	
	1000	average	8.31	12.90	0.75	29.02	31.90	1,060	3,287	
	1000	non-peak	5.54	10.81	0.38	24.30	26.71	296	917	
									6,100	2,226,613
3	1100	peak	4.02	12.29	0.85	41.60	45.71	551	1,708	
	1100	average	8.31	11.83	0.75	26.60	29.23	972	3,012	
	1100	non-peak	5.54	10.51	0.38	23.63	25.97	288	892	
									5,612	2,048,536
4	1200	peak	4.02	11.50	0.85	38.92	42.77	516	1,598	
	1200	average	8.31	11.20	0.75	25.18	27.67	920	2,852	
	1200	non-peak	5.54	10.33	0.38	23.24	25.54	283	877	
									5,327	1,944,402

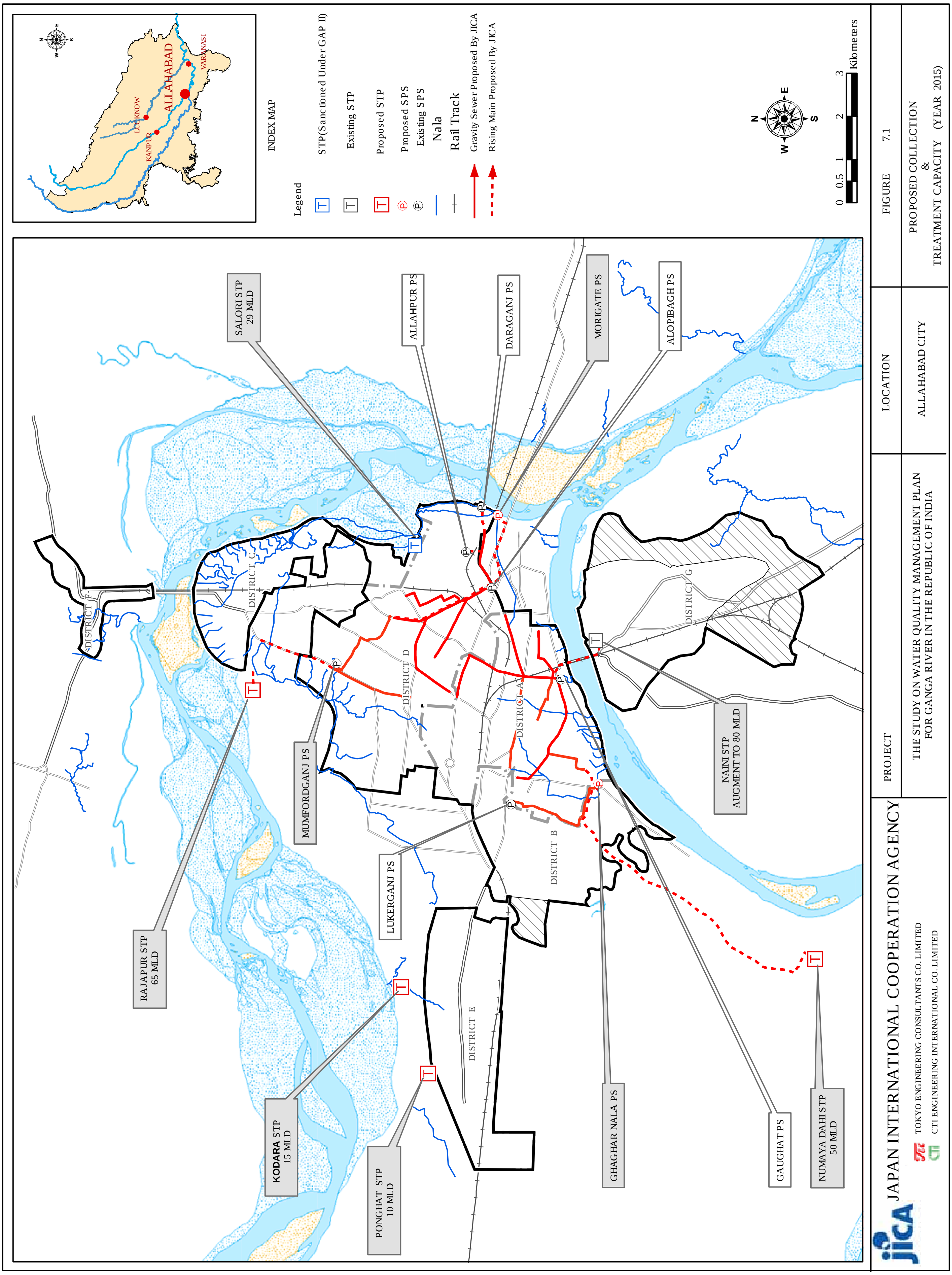
P=9.8*Head*Q/Eff.

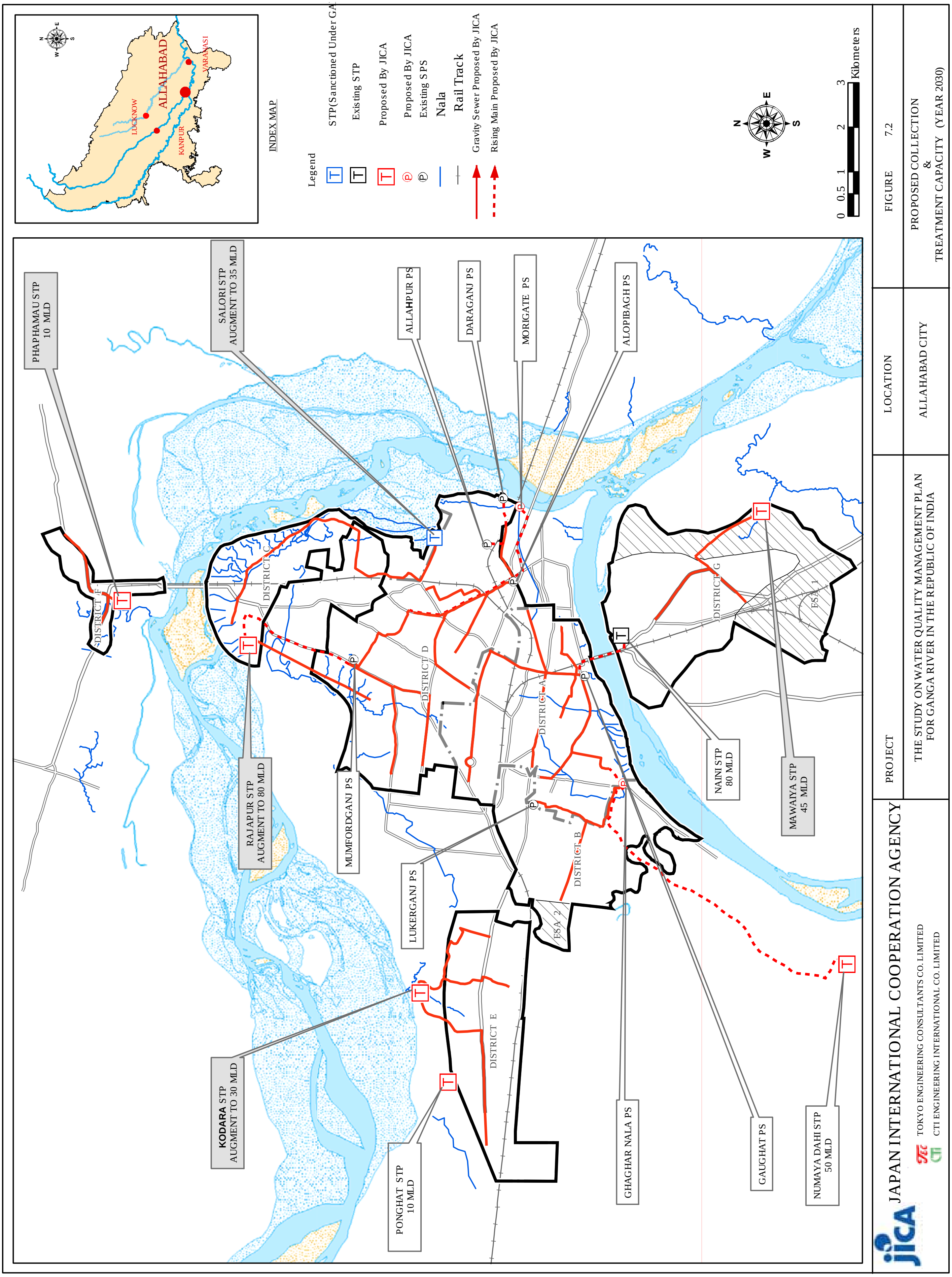
Length of rising main 0 m
Pump cost 36000 Rs/Kw
Pump design period 15 years
Pipeline Design period 30 years
Pipeline Maintenance cost 0.25%
Pump Maintenance cost 3%
Capital discount factor 5%

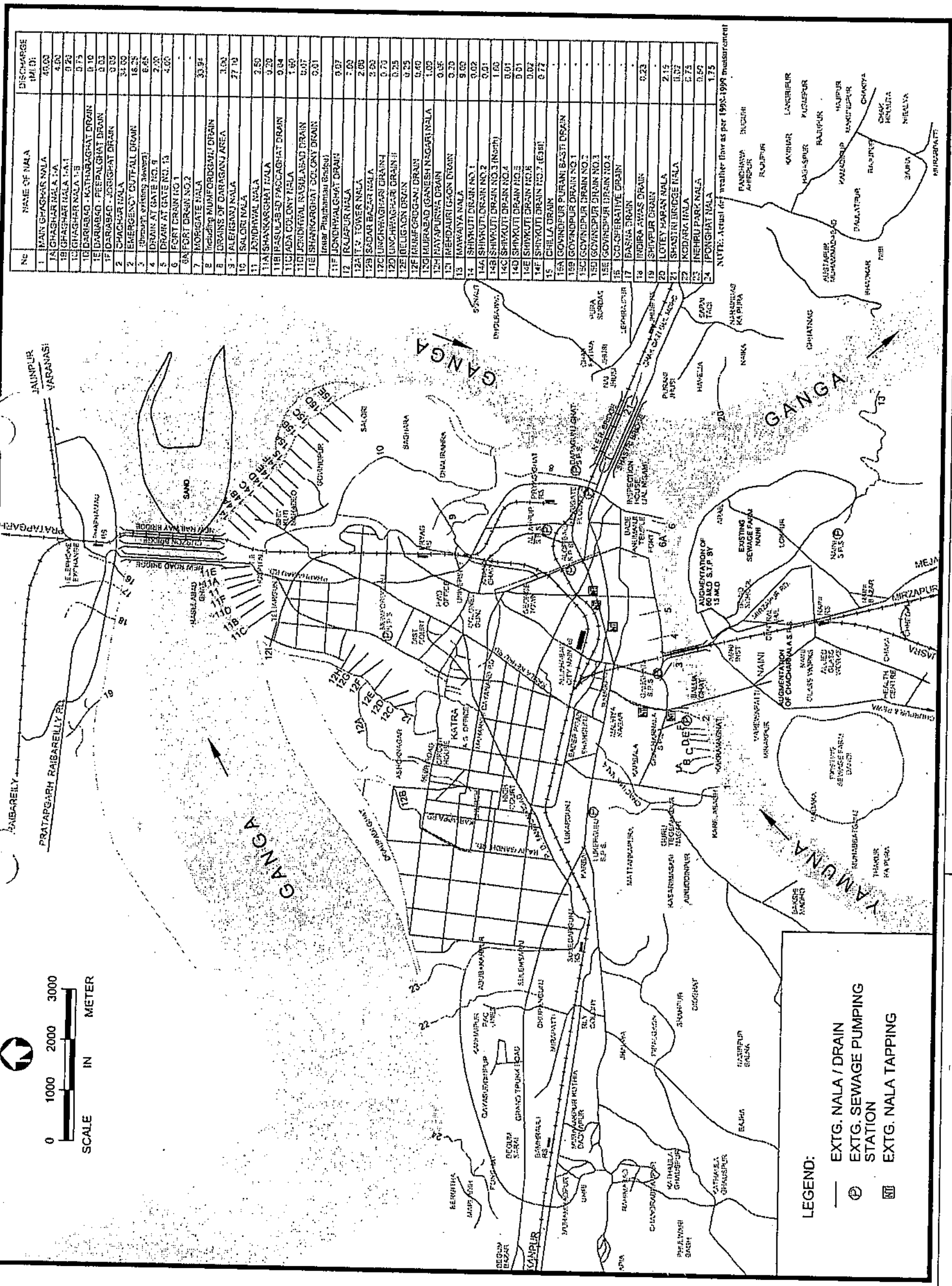
	Diameter	Cost of pumps	Cost of Pipe total	Annual recurring cost: Pipeline maintenance	Pump maintenance	Energy charges	Total	Present Value of annual	Total Cost
	mm								
1	900	13,763,860	28,958,217	72,396	412,916	2,548,141	3,033,453	31,486,201	60,444,418
2	1000	11,994,975	31,818,488	79,546	359,849	2,226,613	2,666,008	27,672,256	59,490,744
3	1100	11,015,287	34,852,127	87,130	330,459	2,048,536	2,466,125	25,597,534	60,449,661
4	1200	10,442,397	42,890,531	107,226	313,272	1,944,402	2,364,901	24,546,860	67,437,391

assume PSC pipe

select 1000mm rising main as most economic size


INDEX MAP
LUCKNOW
KANPUR
ALLAHABAD
VARANASI
Legend
STP(Sanctioned Under GAP II)
Existing STP
Proposed STP
Proposed SPS
Existing SPS
Nala
Rail Track
Gravity Sewer Proposed By JICA
Rising Main Proposed By JICA
0 0.5 1 2 3 Kilometers
SALORI STP 29 MLD
ALLAHPUR PS
DARAGANJ PS
MORIGATE PS
ALOPIBAGH PS
NAINI STP AUGMENT TO 80 MLD
MUMFORDGANJ PS
LUKERGANJ PS
RAJAPUR STP 65 MLD
KODARA STP 15 MLD
PONGHAT STP 10 MLD
GHAGHAR NALA PS
GAUGHAT PS
NUMAYA DAHI STP 50 MLD
DISTRICT A
DISTRICT B
DISTRICT C
DISTRICT D
DISTRICT E
DISTRICT F
DISTRICT G
FIGURE 7.1
PROPOSED COLLECTION & TREATMENT CAPACITY (YEAR 2015)
LOCATION
ALLAHABAD CITY
PROJECT
THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO ENGINEERING CONSULTANTS CO. LIMITED
CTI ENGINEERING INTERNATIONAL CO. LIMITED


INDEX MAP
LUCKNOW
ALLAHABAD
VARANASI
KANPUR
Legend
STP(Sanctioned Under GAP)
Existing STP
Proposed By JICA
Proposed By JICA
Existing SPS
Nala
Rail Track
Gravity Sewer Proposed By JICA
Rising Main Proposed By JICA
0 0.5 1 2 3 Kilometers
PHAPHAMAU STP
10 MLD
SALORI STP
AUGMENT TO 35 MLD
ALLAHPUR PS
DARAGANJ PS
MORIGATE PS
ALOPIBAGH PS
RAJAPUR STP
AUGMENT TO 80 MLD
MUMFORDGANJ PS
LUKERGANJ PS
KODARA STP
AUGMENT TO 30 MLD
PONGHAT STP
10 MLD
GHAGHAR NALA PS
GAUGHAT PS
NUMAYA DAHI STP
50 MLD
NAINI STP
80 MLD
MAWAIYA STP
45 MLD
DISTRICT A
DISTRICT B
DISTRICT C
DISTRICT D
DISTRICT E
DISTRICT F
DISTRICT G
ESA 1
ESA 2
FIGURE 7.2
PROPOSED COLLECTION
&
TREATMENT CAPACITY (YEAR 2030)
LOCATION
ALLAHABAD CITY
PROJECT
THE STUDY ON WATER QUALITY MANAGEMENT PLAN
FOR GANGA RIVER IN THE REPUBLIC OF INDIA
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO ENGINEERING CONSULTANTS CO. LIMITED
CTI ENGINEERING INTERNATIONAL CO. LIMITED



No	NAME OF NALA	DISCHARGE (MLD)
1	MAIN GHAGHAR NALA	40.00
1A	GHAGHAR NALA 1-A	4.00
1B	GHAGHAR NALA 1-A-1	0.20
1C	GHAGHAR NALA 1-B	0.75
1D	DARIABAD - KATHARAGHAT DRAIN	0.10
1E	DARIABAD - PEEPALGHAT DRAIN	0.03
1F	DARIABAD - JOGIGHAT DRAIN	0.05
2	CHACHAR NALA	34.00
2	EMERGENCY OUTFALL DRAIN	16.25
3	(through existing sewers)	6.65
4	DRAIN AT GATE NO. 9	2.00
5	DRAIN AT GATE NO. 13	4.00
6	FORT DRAIN NO 1	-
6A	FORT DRAIN NO.2	-
7	MORIGATE NALA	33.94
8	Including MUMFORDGANJ DRAIN	
8	DRAINS OF DARAGANJ AREA	3.00
9	ALENGANJ NALA	27.10
10	SALORI NALA	
11	JONDHWAL NALA	2.50
11A	SHANKARGHAT NALA	0.20
11B	RASULABAD PACCAGHAT DRAIN	0.04
11C	ADA COLONY NALA	1.60
11D	JONDHWAL RASULABAD DRAIN	0.07
11E	SHANKARGHAT COLONY DRAIN	0.01
	(near Phaphamau Bridge)	
11F	JONDHWALGHAT DRAIN	0.07
12	RAJAPUR NALA	7.00
12A	T.V. TOWER NALA	2.00
12B	SADAR BAZAR NALA	2.00
12C	UNCHWAGHARI DRAIN-I	0.70
12D	UNCHWAGHARI DRAIN-II	0.25
12E	BELIGAON DRAIN	0.25
12F	MUMFORDGANJ DRAIN	0.40
12G	MUIRABAD (GANESH NAGAR) NALA	1.00
12H	NAYAPURWA DRAIN	0.05
12I	MEHDAURI GAON DRAIN	0.20
13	MAWAIYA NALA	9.00
14	SHIVKUTI DRAIN NO.1	0.02
14A	SHIVKUTI DRAIN NO.2	0.01
14B	SHIVKUTI DRAIN NO.3 (North)	1.60
14C	SHIVKUTI DRAIN NO.4	0.01
14D	SHIVKUTI DRAIN NO.5	0.01
14E	SHIVKUTI DRAIN NO.6	0.02
14F	SHIVKUTI DRAIN NO.7 (East)	0.72
15	CHILLA DRAIN	-
15A	GOVINDPUR PURANI BASTI DRAIN	-
15B	GOVINDPUR DRAIN NO.1	-
15C	GOVINDPUR DRAIN NO.2	-
15D	GOVINDPUR DRAIN NO.3	-
15E	GOVINDPUR DRAIN NO.4	-
16	CO-OPERATIVE DRAIN	-
17	BASNA DRAIN	-
18	INDIRA AWAS DRAIN	0.23
19	SHIVPUR DRAIN	-
20	LOTEY HARAN NALA	2.15
21	SHASTRI BRIDGE NALA	0.07
22	KODARA NALA	0.75
23	NEHRU PARK NALA	0.50
24	PONGHAT NALA	1.75

NOTE: Actual dry weather flow as per 1998-1999 measurement

JICA JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO ENGINEERING CONSULTANTS CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.

PROJECT	LOCATION	FIGURE 7.3
THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA	ALLAHABAD CITY	Location Map of Nala

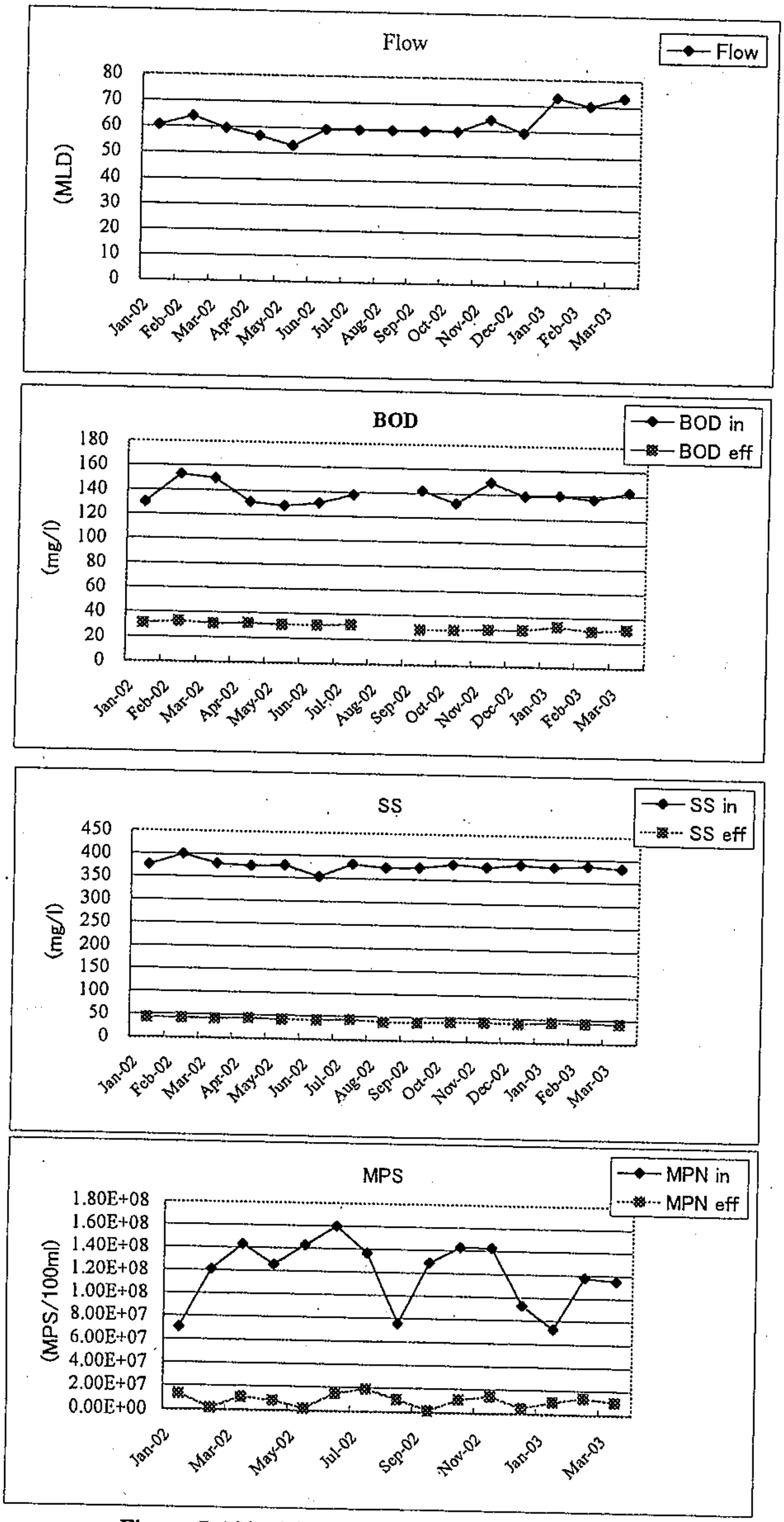
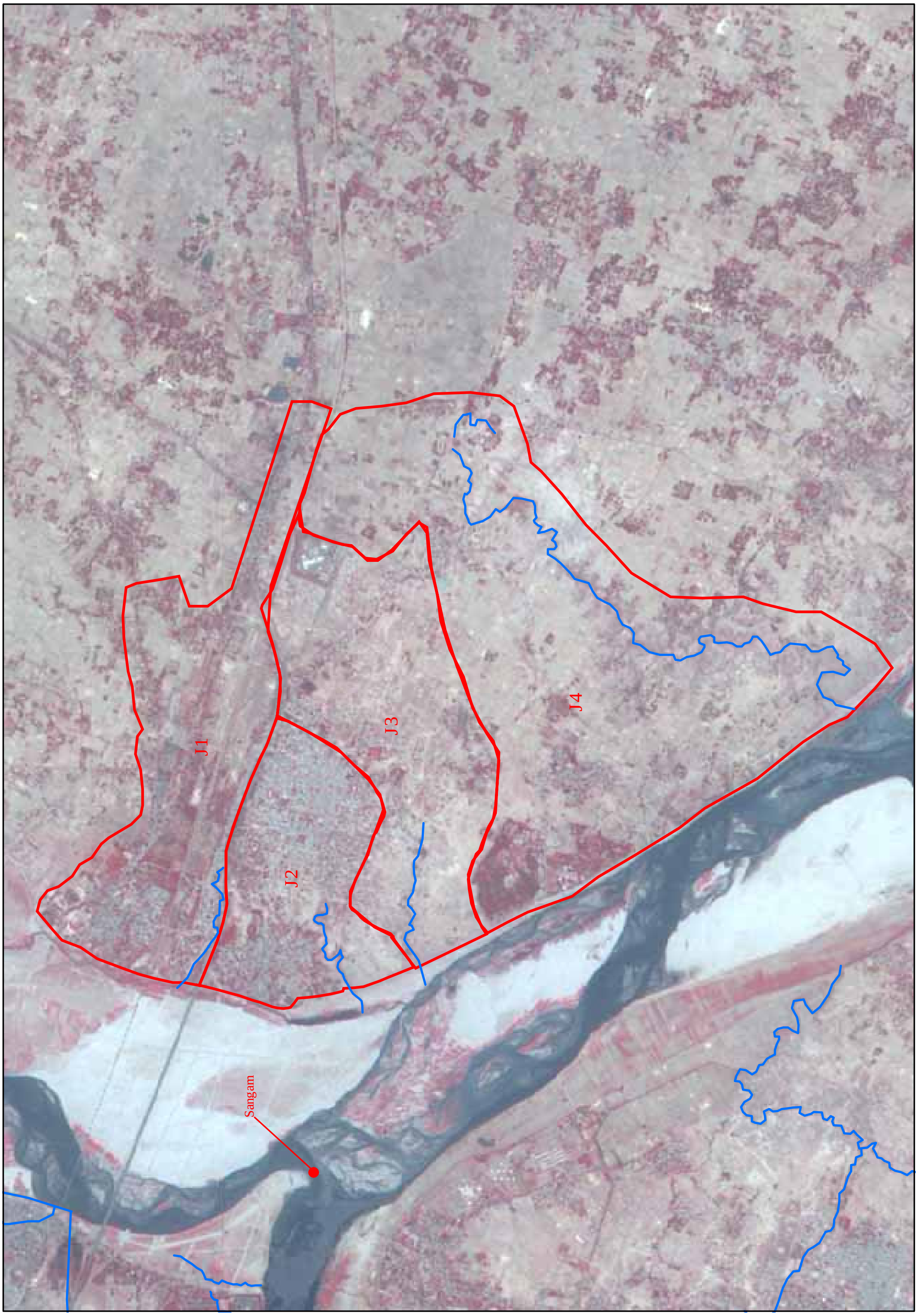


Figure 7.4 Nani STP: Average Monthly Data



JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO ENGINEERING CONSULTANTS CO. LIMITED
CTI ENGINEERING INTERNATIONAL CO. LIMITED

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

LOCATION
ALLAHABAD CITY

Figure 7.5
JHUNSI AREA

CHAPTER 8

IMPLEMENTATION STRATEGY AND PHASING

CHAPTER 8 IMPLEMENTATION STRATEGY AND PHASING

A number of options were evaluated in Chapter 6 leading to the selection of a recommended plan. The details of the sewerage infrastructure, location, capacity, and type of treatment process were determined in Chapter 7. This section of the Master Plan identifies the implementation strategy and recommends priorities. It also identifies the required infrastructure components, along with implementation phases.

8.1 OVERALL STRATEGY

Sewerage will be developed gradually, with a series of interventions implemented in a phased approach. Although the time line to full build out cannot be predicted with any certainty, and may not happen within the 2030 planning horizon, it is assumed that all the improvements will take place within the planning horizon. The implementation of sewerage over the planning horizon has been divided into two stages:

- Stage I: immediate interventions required by 2015
- Stage II: continuing long-term development of sewerage 2016 to 2030

8.1.1 Stage I

The following Stage I projects have been identified as critical needs and should be implemented within one to five years following the adoption of the Master Plan:

- Augmentation of existing treatment works
- Construction of new treatment plants
- Interception of all drains and diversion to treatment
- Major trunk sewers and pumping stations required to service densely populated areas and convey sewage to treatment works
- Cleaning and rehabilitation of existing sewers
- Capacity building for project implementation organization
- Capacity building of O&M organizations for sewers and treatment plant
- Reorganization of existing trunk sewers to divert sewage to new treatment works
- The extension of trunk sewers in all areas of the city that do not have adequate sewerage infrastructure
- Improving branch sewers in existing sewered areas
- Development of branch sewers in formerly unserviced areas
- An on-going program of house connections to increase amount of wastewater collected and treated
- Removing informal connections of storm drains to the sewer system
- Disconnecting informal connections of branch sewers to storm drains.
- On-going capacity building for O&M organizations

8.1.2 Stage II

Stage-II: projects implemented beyond 2015 are required to service population growth in new areas. These projects will generally include:

- Additional trunk sewers in new growth areas
- Replacement pumping equipment and/or augmentation of pumping capacity
- Augmentation of capacity at treatment plants to handle increased flows over the planning horizon.
- On-going program for development of branch sewers and improving house connections ratios.

8.2 TIMING FOR IMPLEMENTATION OF SEWERAGE COMPONENTS

District wise delineation of the sewerage scheme is presented in Chapter 7 Figure 7.1 for 2015 and Figure 7.2 for 2030. The overall scheme will consist of 7 separate sewerage Districts each with its own treatment plant.

8.2.1 Treatment Plants

Treatment plants for each District have been selected on the basis of cost comparisons and technology options for meeting required effluent standards. Capacities are for full build out conditions in 2030.

Table 8.1 Phase-wise Implementation of Treatment Plant Capacity

(mld)

STP	District	Status	2003	2015	2030
Naini STP	A	E/A	60	80	80
Numaya Dahi STP	B	P	-	50	50
Salori STP	C	S/A	-	29	35
Rajapur STP	D	P	-	65	80
Kodara STP	E	P	-	15	30
Ponghat STP	E	P	-	10	10
Phaphamau STP	F	P	-	-	10
Mawaiya STP	G	P	-	-	45
Total			60	249	340

STP	District	Status	Process	Effluent discharge	Disinfection
Naini STP	A	E/A	ASP	Irrigation and Ganga River	Add chlorination
Numaya Dahi STP	B	P	WSP	Irrigation and Yamuna River	Maturation ponds
Salori STP	C	S/A	FAB	Ganga River	Chlorination
Rajapur STP	D	P	UASB++	Ganga River	Chlorination
Kodara STP	E	P	UASB++	Ganga River	Chlorination
Ponghat STP	E	P	WSP	Irrigation and Ganga River	Maturation ponds
Phaphamau STP	F	P	WSP	Ganga River	Maturation ponds
Mawaiya STP	G	P	UASB++	Ganga River	Chlorination

E: Existing, A: Augment, S: Sanctioned

8.2.2 Collection System Components

Proposed trunk sewers, pumping stations and preliminary alignments are presented in layout drawings C7 to C13 in Appendix C. The drawings also identify tributary areas used to calculate hydraulic capacity of the pipe. A phase wise summary of required collection infrastructure improvements is presented in Table 8.2.

Table 8.2 Phase wise Implementation of Collection System Improvements

Implementation period	Pump stations	Trunk sewers/ Rising mains	Lateral and Branch sewers
Stage I (- 2015)	**Improve and Augment Capacity:** District B Lukerganj SPS District D Morigate SPS Daraganj SPS Alopibagh SPS Mumfordganj MPS **New Pump station:** District B Ghaghar Nala MPS	**Replace Old Trunk sewers** District A **Reorganize Existing Sewer Network:** District A, D **New Trunk Sewers:** District A, B, D **New Rising Mains:** District B Ghaghar Nala MPS District D Alopibagh SPS Mumfordganj SPS	District A, B, D
Stage II (2016-2030)		**New Trunk Sewers** - Districts B, C, E, F, G	On-going + District B, C, E, F, G

8.2.3 Discussion

(1) District A, B, D

Most of the existing trunk sewers in the city center are overloaded and do not have sufficient carrying capacity for future populations. These sewers can either be paralleled or replaced by larger pipes in areas that are congested. Furthermore many sewers are probably in poor condition and in need of cleaning or repairs.

It is necessary to limit the sewage load at Gaughat MPS to 80 mld and therefore existing trunk sewers must be reorganized and diverted to other catchments.

Existing sewers located north of GT road and west of Stanley road must be reorganized and diverted to the catchment area for proposed Rajapur STP, District D. Similarly sewage collected at Alopibagh SPS will be conveyed to Rajapur STP. Therefore the exisiting1600 mm diameter rising main to Gaughat MPS must be abandoned. The timing of these two interventions should coincide with development of new trunk sewers in District D and the construction of Rajapur STP.

Existing sewers located west of Nurullah road must be reorganized and diverted to the catchment area proposed for Numaya Dahi STP, District B. Similarly sewage collected at Lukerganj SPS will be conveyed to Ghaghar nala MPS. Therefore existing rising mains discharging to gravity sewers in District A must be abandoned. The timing of these interventions should coincide with development of new trunk sewers in District B, the reconstruction of Lukerganj SPS, construction of Numaya Dahi STP and Ghaghar nala MPS.

Expansion of Naini STP to 80 mld should be undertaken as soon as possible since flow received at Gaughat MPS has already reached this level. Rehabilitation and reorganization of sewers in District A, as well as implementation of sewerage in District B and D is necessary before 2015 in order to prevent overflows at Gaughat MPS. Furthermore, sewerage in District B and tapping of Ghaghar nala is considered critical because the pollutant load to Yamuna river is significant and within close proximity of the Sangam.

(2) District C

A treatment plant and tapping of Salori nala is already being implemented by UPJN under GAP-II. Sewage projections indicate that the treatment plant will need to be augmented to 35 mld before 2020. Although Salori nala will be intercepted, a number of smaller drains will continue to pollute Ganga river. Therefore main trunk sewers leading to the treatment plant should be implemented. This will set the foundation for implementing branch sewers and house connections over coming years to gradually reduce the amount of wastewater reaching surface drains.

(3) District E

Sewerage in District E is less urgent because population is relatively small and population density in many parts is less than 120 persons per hectare. However 3 nalas in this district discharge a total of approximately 9 mld of wastewater to the Ganga river. UPJN has planned to tap these nalas under GAP but specific proposals have not yet been developed. The Master Plan proposes to intercept and treat these flows by 2015. Therefore the treatment works and tapping facilities should be constructed at the tail end of the nalas. The trunk sewer network can be constructed after this and connected to the treatment works.

(4) District F and G

Sewerage in Districts F, G is less urgent because populations are relatively small and population density in many parts is less than 120 persons per hectare. The new bridge across Yamuna river will act as a likely catalyst for rapid growth in District G to the south. Therefore the new treatment plant at Mawaiya and connecting outfall sewer should be implemented some time after 2015. This will lay the foundation for the orderly development of the future wastewater collection system in this area.

8.3 PRIORITY PROJECTS

The sewerage system is required to improve sanitary conditions in the city with the goal of removing wastewater from open drains and improving water quality in water bodies. In the beginning, priority should be given to developing sewerage in areas upstream of water supply intake and the bathing area at Sangam.

Development of sewerage should then follow in the downstream direction with priority given to diverting sewage away from the rivers and improving services in the most densely populated areas. Finally sewerage should be implemented in new growth areas.

The timing of any sewerage development will depend on actual population growth and growth patterns. It is also essential that sewerage development be integrated with development of water supply. Installation of sewers in areas where water distribution is inadequate will lead to failure of the system. Delayed installation of sewers in areas that have adequate water supplies will lead to discharge of sewage to open drains and pollution of the environment.

Priority projects are defined as projects that should be implemented as soon as possible to achieve pollution reduction targets. Projects that have already been sanctioned are not identified because funding is in place and it is assumed they will be fully implemented in the short term.

Priority projects: selected for detailed investigations in subsequent feasibility studies are listed in order of priority in Table 8.3:

Table 8.3 Identification of Priority Projects

<table>
<tr><th>District</th><th>Priority</th></tr>
<tr><td>(1) District A

Projects
▪ Augmentation of Naini STP from 60 to 80 mld
▪ Rehabilitation of Gaughat MPS and Chachar nala SPS
▪ Rehabilitation of existing trunk sewers and installation of new trunk sewers

Rational
▪ District A includes the old city. It is densely populated and discharges the largest amount of raw sewage to the rivers.
▪ Further increase in sewage is expected as the population increases.
▪ Sewer network has been well developed in this District.
▪ Most of sewage in this area has been collected and conveyed to Gaughat MPS but flow in excess of capacity at Naini STP is discharged to Yamuna river.
▪ Early reduction of 20 mld sewage discharged to the river is achieved by augmentation of Naini STP.</td><td>

A
A
A</td></tr>
<tr><td>(2) District B

Projects
▪ Rehabilitation of Lukerganj SPS
▪ Construction of Ghaghar nala SPS
▪ Construction of Numaya Dahi STP
▪ Installation of new trunk sewers
▪ Installation of rising main to STP

Rational
▪ Catchment area of Lukerganj SPS is also densely populated and sewage from this area drains into District A.
▪ The sewage flow in this area should be separated from District A to reduce the load on Gaughat MPS and Naini STP.</td><td>

A
A
A
A
A</td></tr>
</table>

(3) District C	
Projects	
▪ Construction of Salori STP (Sanctioned)	-
▪ Construction of interceptor and SPS (Sanctioned)	-
▪ Installation of new trunk sewers along Salori nala	B
Rational	
▪ The population density of catchment area of Salori STP is not so high.	
▪ Salori nala is within a close proximate of Sangam confluence and raw sewage discharged into the Ganga river affects the bathing people.	
▪ Salori STP is already sanctioned	
▪ UPJN expects to install a trunk sewer along Salori nala.	

(4) District D	
(D1- Catchment of Alopibagh PS and developed area)	
Projects	
▪ Construction of Rajapur STP, tapping facility	A
▪ Rehabilitation of Alopibagh PS	A
▪ Upgrading pumping stations, Morigate, Mumfordganj, Allahpur, Daraganj	A
▪ Rehabilitation/replacement of existing trunk sewers and installation of new trunk sewers and rising mains	
Rational	
▪ District D1 is densely populated area and sewage flows into District A.	
▪ The sewage flow in this area should be separated from District A to reduce the load of Naini STP.	

(5) District D	
(D2 - Low land area near Rajapur nala and less developed area)	
Projects	
▪ Construction of Rajapur nala tapping facility and SPS	A
▪ Installation of new trunk sewers	B
Rational	
▪ The population density is lower than that of the catchment area of Alopibagh SPS and the sewage amount is also small. The priority of installation of truck sewers is low.	

(6) District E	
Projects	
▪ Construction of Kodara STP and tapping facility	A
▪ Construction of Ponghat STP and tapping facility	A
Rational	
▪ Nalas in this district contribute significant pollutant load to Ganga river	
▪ This area is developing quickly.	

(7) District F	
Projects	
▪ Construction of Phaphamau STP	B
▪ Installation of new trunk sewers	B
Rational	
▪ At present small population and low population densities	
▪ Future growth area	

(8) District G	
Project list	B
▪ Construction of Mawaiya STP	B
▪ Installation of new trunk sewers	
Rational	
▪ Low population densities	
▪ Discharging downstream of Sangam confluence	

A: Priority works selected for Feasibility Study, to be implemented before 2015

B: Works to be implemented after 2015

CHAPTER 9

COST ESTIMATES

CHAPTER 9 COST ESTIMATES

9.1 CAPITAL COST ESTIMATE

9.1.1 General

The total estimated direct construction costs including a 20% physical contingency for planning level estimates and land acquisition are as follows:

(Crores)

Item	Stage I	Stage II	Total
Direct Cost	241.1	333.1	574.2
Physical Contingency (20%)	48.2	66.6	114.8
Land Acquisition	50.7	11.3	62.0
Total	340.0	411.0	751.0

Direct cost does not include house connection cost

Summary of direct cost is presented stage wise in Table 9.1 and the breakdown of component costs is represented in the form of a pie chart in Figure 9.1.

All costs are with 2003 base prices, in Indian Rupees. Taxes and duties vary depending on the equipment or material supplied therefore these are included in the unit costs.

The estimate of investment costs has been worked out based on a phase wise implementation plan that corresponds to priorities and timeframes discussed in the report. The following costs have been included in estimated costs for project evaluation:

Item	Capital	O&M	Replacement
Existing facilities and Sanctioned projects (GAP-II)	X	O	O
Augmenting existing pump stations and treatment plants or replacing outdated equipment	O	O	O
Proposed master plan projects	O	O	O

X = not included O = included in cost estimate

The investment costs for Stage II (2016 to 2030) include an estimate of replacement costs for mechanical/electrical equipment installed during the first phase that will have reached the end of their useful life after 15 years.

Total costs for the facilities identified in the Master Plan are comprised of the following items:

- Direct construction cost based on preliminary design of facilities (based on unit costs including taxes and duties) plus 10% for contractor’s profit.
- Land acquisition cost
- Engineering cost: Add 15% of direct construction cost for design and construction supervision
- Administrative costs: Add 10% of direct construction cost for centage fees related to project preparation and supervision (refer Indo-Dutch project 4% preparation + 6% admin. during construction)
- Physical contingency: add 20% to the sum of direct construction cost

9.1.2 Capital Costs for Trunk Sewers and Manholes

The cost estimate for laying trunk sewers and laterals has been prepared on the basis of preliminary design for Master Plan.

The estimated costs include ancillary items like excavation, reinstatement of road surfaces, provision of protection works, closed timbering, and cost of bedding. The cost per linear meter of pipe includes the cost of manholes. The cost of new trunk sewers and laterals is presented in Table 9.2. Total length of trunk sewers and laterals is approximately 65 km. The cost of trunk sewers and laterals is estimated at Rs. 1,592 million.

9.1.3 Capital Costs for Branch Sewers

The capital cost of branch sewers has been worked out on the basis of cost per unit length of 1,000 Rs/m (Jal Sansthan Allahabad) assuming 250mm diameter concrete pipe. The average length of branch sewer per hectare is 385 m/ha which has been worked out from a review of sewer drawings for typical colonies and urban areas.

The estimated cost of branch sewers includes cost of manholes, road reinstatement and other ancillary works. The estimated cost of branch sewers is presented in Table 9.3. The total cost of branch sewers is worked out Rs. 2,164 million.

9.1.4 Capital Costs for House Connections

The number of house connections to be made during various project years has been assessed on the basis of number of dwellings calculated from census population and family size. The number of houses connected to the wastewater collection system will reach up to 80% by the end of Stage II. The connection ratios at each phase have been identified in Chapter 5 “Sewerage Planning Framework”.

The unit cost of house connections is taken as Rs. 7,750 / connection. This unit cost is obtained from discussions with Jal Sansthan Allahabad and costs identified in Allahabad sewerage master plan adjusted to 2003 cost base using wholesale price index. Costs for house connection are estimated for each District in Table 9.4.

9.1.5 Capital Costs for Sewage Pumping Stations

The total capital cost of pumping stations has two major components: civil works and electro-mechanical works. The cost of each has been worked out separately as shown in Table 9.5.

The costs are worked out on the basis of cost per mld developed from a review of recent UPJN tenders and DPR cost estimates. The following formulae and costs are applied depending on the type of pump station:

Type	Civil works	Electro-mechanical	Electrical service
Submersible < 6 mld	$y = 0.1073x + 2.7675$	$y = 1.0x$	$y = 0.8x$
Submersible > 6 mld	$y = 0.1679x + 1.3616$	$y = 0.3x$	$y = 0.8x$
Centrifugal	$y = 26.958Ln(x) - 80.598$	$y = 0.2462x + 5.0009$	$y = 25.0x$

x: Design capacity in mld, y: Cost in million Rs.

The electro-mechanical costs include the cost of diesel generators. The cost of electrical service entrance assumes 11 kV, and includes an average transmission line length of 5 km. The cost of new pumping stations and upgrades to existing is estimated at Rs. 593 million.

9.1.6 Capital Costs for Rising Mains

The size and other details of rising mains has been worked out on the basis of preliminary design. All rising mains are estimated on the basis of unit cost per length for pre-stressed concrete pipe. Costs include installation, jointing, and testing, and connection to outfall sewer.

Cost details are provided in Table 9.6. The total length of new rising mains is 16 km and the estimated cost is Rs. 219 million.

9.1.7 Capital Costs for Treatment Plants

Capital costs of treatment plants have been worked out in Chapter 6 "Evaluation" for comparison and selection of treatment processes. Capital costs per unit mld are based on a review of treatment plants constructed under GAP and YAP presented in Supporting Report (Vol.-III-11). The estimated cost of treatment works is presented in Table 9.7. The total cost is Rs. 1,089 million. The estimated cost includes treatment units along with piping, pumping, cost of laboratory, administrative building, electrical sub-station, site development and boundary walls. The cost of dual fuel engine generators is included for treatment processes that produce methane. Costs of land acquisition have been identified separately in Table 9.8.

9.2 ANNUAL O&M COSTS

Effective operation and maintenance is essential for the success of any sewerage system. Operation and maintenance involves the following major components:

- Operation, maintenance and monitoring personnel
- Parts, equipment and machinery
- Energy costs

Total O&M costs are summarized in Table 9.10.

Annual repair and maintenance costs at pumping stations are estimated as a percentage of capital costs using the following factors as adopted by UPJN:

Table 9.11 Unit Operation and Maintenance Costs

Sl.	Description of items	Economic life (years)	Annual repair and maintenance cost as % of capital cost
1	Civil structures	30	1.5
2	Pumps	15	3.0
3	Pipelines	30	0.25
4	Electrical	15	3.0
5	Diesel generators	15	3.0

Source: UPJN Detailed Project Reports, Allahabad and Lucknow

Energy costs for pumping stations are calculated on the basis of electricity required to operate the pumps as calculated from the discharge and pumping head. The cost of electricity is taken as Rs 3.1 per kWhr from the rate schedule issued by U.P. Power Corporation, August 2003. Recurring costs (excluding staff) for pumping stations are presented in Table 9.12.

Energy costs for treatment plants is worked out on the basis of unit consumption rates per mld identified in Supporting "Report Case Study of Sewage Treatment Plants". Recurring costs for treatment plants are identified in Table 9.13.

Proposals regarding staffing are described in the following sub-sections.

9.2.1 Staff

The number of staff required for carrying out regular operational, preventive and corrective maintenance activities can be grouped into the following categories:

- Personnel for sewer maintenance
- Personnel for sewage pumping stations
- Personnel for operation and maintenance of sewage treatment works
- Personnel for process control

Staff requirements for pump stations and treatment plants are in accordance with directives issued for GAP projects by UP Ministry for Urban Development. Annual recurring costs on staffing is based on the manpower required and salaries that have been given by UPJN Allahabad for 2002, and increased by 10% to bring them to 2003 base.

(1) Sewer Maintenance

Sewer maintenance generally involves regular inspection of all sewers, sewer cleaning operations, both preventive and corrective, and occasional repairs to manholes. Category and extent of personnel required for these activities have been worked out on the basis of quantity of work. Recommended personnel requirements for this component are presented in Table 9.14. A total of 4 gangs are recommended for Stage I, and 6 gangs for Stage II.

(2) Sewage Pumping Stations

The personnel requirements for operation and maintenance of sewage pumping stations vary depending on the size of the station. Staff requirements for pump stations are presented in Table 9.15 in accordance with directives issued for GAP projects by UP Ministry for Urban Development.

(3) Sewage Treatment Plants

The personnel requirement for operation and maintenance of treatment plants vary depending on the size of the station. Staff requirements for GAP projects are determined by UP Ministry for Urban Development and presented in Table 9.16 to table 9.23.

9.3 COST SCHEDULE

The annual investment costs and recurring costs for implementing the Sewerage Master Plan are presented for each district in Table 9.24. The schedule of costs is based on the implementation schedule and priorities discussed in previous sections. The cost breakdown of projects identified for implementation during Stage I is listed in order of priority in Table 9.25.

Table 9.1 Preliminary Capital Cost Estimate: Summary

Base year : 2003
City: Allahabad

Total

Item	Cost (Rs. million)		
	Stage I	Stage II	Total
	-2015	2016-2030	
Trunk sewers (including manholes)	672.89	919.36	1,592.25
Branch sewers	221.08	1,942.42	2,163.50
Pumping stations	478.60	113.90	592.50
Rising mains	218.82	0.00	218.82
Treatment plants	820.00	268.60	1,088.60
Replacement of M/E assets	0.00	86.40	86.40
Sub-total	2,411.39	3,330.68	5,742.07
Physical Contingency (20%)	482.28	666.13	1,148.41
Cost of detailed engineering (15%)	361.70	499.60	861.31
Cost of project administration (10%) (1)	241.14	333.08	574.21
Land acquisition	507.20	113.20	620.40
Sub-total	1,592.32	1,612.01	3,204.33
Grand total	4,003.71	4,942.69	8,946.40

Direct Cost (including land acquisition)	2,918.59	3,443.88	6,362.47
House connections	220.08	1,393.36	1,613.44

Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Allahabad

District-A

Item	Cost (Rs. million)		
	Stage I	Stage II	Total
	Before 2010	2016-2030	
Trunk sewers (including manholes)	332.34	111.76	444.10
Branch sewers	76.29	178.01	254.30
Pumping stations	4.60	31.30	35.90
Rising mains	0.00	0.00	0.00
Treatment plants	54.00	0.00	54.00
Replacement of M/E assets	0.00	86.40	86.40
Sub-total	467.23	407.47	874.70
Physical Contingency (20%)	93.45	81.49	174.94
Cost of detailed engineering (15%)	70.08	61.12	131.21
Cost of project administration (10%) (1)	46.72	40.75	87.47
Land acquisition	0.00	0.00	0.00
Sub-total	210.25	183.36	393.62
Grand total	677.48	590.83	1,268.32

House connections	108.63	202.93	311.56

Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Allahabad

District-B

Item	Cost (Rs. million)		
	Stage I	Stage II	Total
	Before 2010	2016-2030	
Trunk sewers (including manholes)	88.18	17.32	105.50
Branch sewers	93.62	184.12	277.74
Pumping stations	217.70	26.10	243.80
Rising mains	138.25	0.00	138.25
Treatment plants	80.00	0.00	80.00
Replacement of M/E assets	0.00	0.00	0.00
Sub-total	617.75	227.54	845.29
Physical Contingency (20%)	123.55	45.51	169.06
Cost of detailed engineering (15%)	92.66	34.13	126.79
Cost of project administration (10%) (1)	61.78	22.75	84.53
Land acquisition	279.20	0.00	279.20
Sub-total	557.19	102.39	659.58
Grand total	1,174.94	329.93	1,504.87

House connections	58.77	172.51	231.28

Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Allahabad

District-C

Item	Cost (Rs. million)		
	Stage I	Stage II	Total
	Before 2010	2016-2030	
Trunk sewers (including manholes)	0.00	248.26	248.26
Branch sewers	0.00	249.10	249.10
Pumping stations	0.00	0.00	0.00
Rising mains	0.00	0.00	0.00
Treatment plants	0.00	27.60	27.60
Replacement of M/E assets	0.00	0.00	0.00
Sub-total	0.00	524.96	524.96
Physical Contingency (20%)	0.00	104.99	104.99
Cost of detailed engineering (15%)	0.00	78.74	78.74
Cost of project administration (10%) (1)	0.00	52.50	52.50
Land acquisition	0.00	0.00	0.00
Sub-total	0.00	236.23	236.23
Grand total	0.00	761.19	761.19

House connections	0.00	222.36	222.36

Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Allahabad

District-D

Item	Cost (Rs. million)		
	Stage I	Stage II	Total
	Before 2010	2016-2030	
Trunk sewers (including manholes)	252.37	142.43	394.80
Branch sewers	51.17	470.36	521.53
Pumping stations	256.30	56.50	312.80
Rising mains	80.57	0.00	80.57
Treatment plants	625.00	45.00	670.00
Replacement of M/E assets	0.00	0.00	0.00
Sub-total	1,265.41	714.29	1,979.70
Physical Contingency (20%)	253.08	142.86	395.94
Cost of detailed engineering (15%)	189.81	107.14	296.96
Cost of project administration (10%) (1)	126.54	71.43	197.97
Land acquisition	136.00	0.00	136.00
Sub-total	705.43	321.43	1,026.86
Grand total	1,970.84	1,035.72	3,006.56

House connections	52.68	382.59	435.27

Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Allahabad

District-E

Item	Cost (Rs. million)		
	Stage I	Stage II	Total
	Before 2010	2016-2030	
Trunk sewers (including manholes)	0.00	208.17	208.17
Branch sewers	0.00	357.28	357.28
Pumping stations	0.00	0.00	0.00
Rising mains	0.00	0.00	0.00
Treatment plants	61.00	45.00	106.00
Replacement of M/E assets	0.00	0.00	0.00
Sub-total	61.00	610.45	671.45
Physical Contingency (20%)	12.20	122.09	134.29
Cost of detailed engineering (15%)	9.15	91.57	100.72
Cost of project administration (10%) (1)	6.10	61.05	67.15
Land acquisition	92.00	0.00	92.00
Sub-total	119.45	274.71	394.16
Grand total	180.45	885.16	1,065.61

House connections	0.00	159.23	159.23

Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Allahabad

District-F

Item	Cost (Rs. million)		
	Stage I	Stage II	Total
	Before 2010	2016-2030	
Trunk sewers (including manholes)	0.00	57.51	57.51
Branch sewers	0.00	71.61	71.61
Pumping stations	0.00	0.00	0.00
Rising mains	0.00	0.00	0.00
Treatment plants	0.00	16.00	16.00
Replacement of M/E assets	0.00	0.00	0.00
Sub-total	0.00	145.12	145.12
Physical Contingency (20%)	0.00	29.02	29.02
Cost of detailed engineering (15%)	0.00	21.77	21.77
Cost of project administration (10%) (1)	0.00	14.51	14.51
Land acquisition	0.00	50.00	50.00
Sub-total	0.00	115.30	115.30
Grand total	0.00	260.42	260.42
House connections	0.00	34.69	34.69

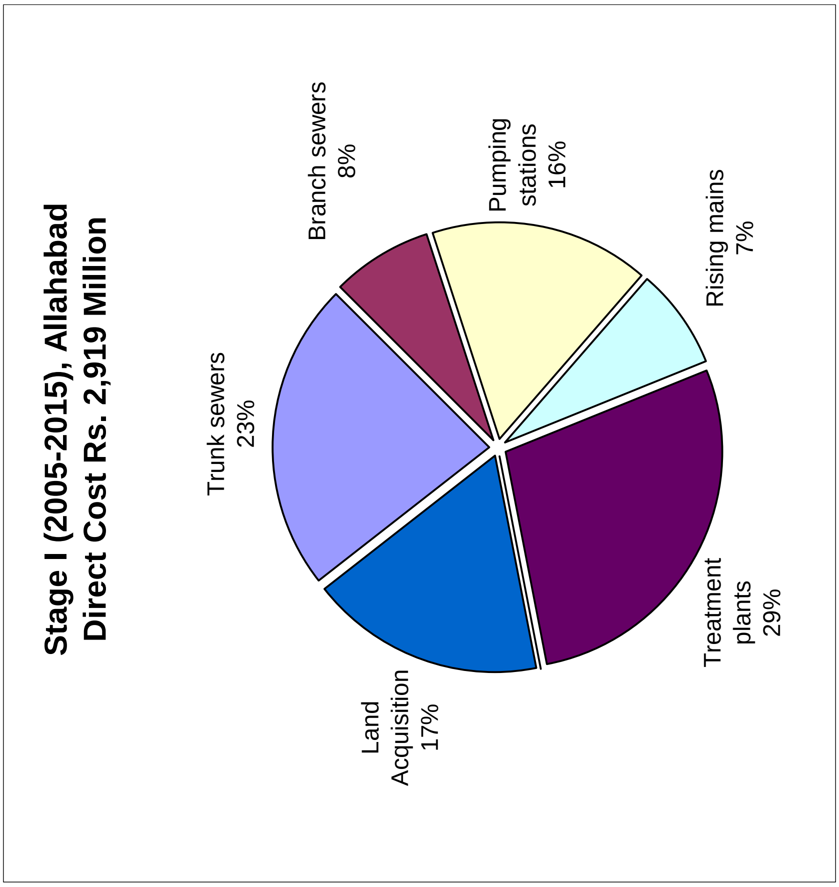
Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Allahabad

District-G

Item	Cost (Rs. million)		
	Stage I	Stage II	Total
	Before 2010	2016-2030	
Trunk sewers (including manholes)	0.00	133.91	133.91
Branch sewers	0.00	431.94	431.94
Pumping stations	0.00	0.00	0.00
Rising mains	0.00	0.00	0.00
Treatment plants	0.00	135.00	135.00
Replacement of M/E assets	0.00	0.00	0.00
Sub-total	0.00	700.85	700.85
Physical Contingency (20%)	0.00	140.17	140.17
Cost of detailed engineering (15%)	0.00	105.13	105.13
Cost of project administration (10%) (1)	0.00	70.09	70.09
Land acquisition	0.00	63.20	63.20
Sub-total	0.00	378.59	378.59
Grand total	0.00	1,079.44	1,079.44
House connections	0.00	219.06	219.06

Note (1): 4% preparation + 6% administration during construction



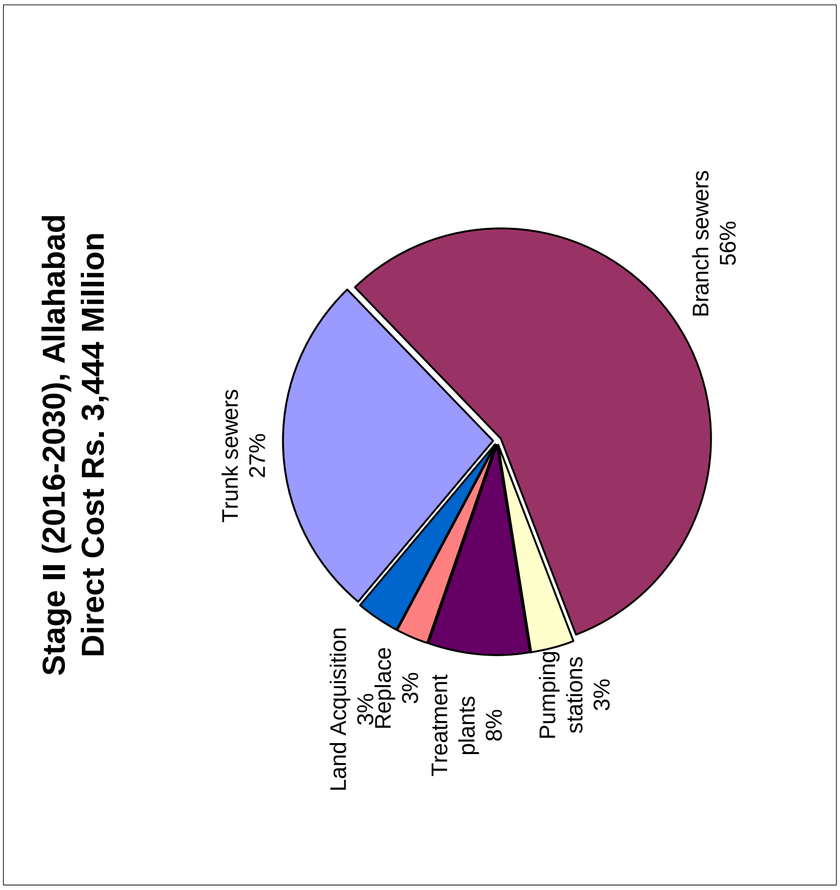


Figure 9.1 Estimated Cost of Sewerage, Breakdown of Direct Construction Cost

Table 9.2 Preliminary Capital Cost Estimate: Trunk Sewers and Laterals (Page 1 of 2)

Base year : 2003
City: Allahabad

District	Node (US)	Node (DS)	Diameter (mm)	depth	length (m)	unit cost (Rs./m)	Cost (Rs. million)		
							Stage I -2015	Stage II 2016-2030	Total
District A									
Rehabilitate Existing Sewer (75% of construct cost)									
	3	7	600	D	700	17,649	12.35		
	7	Gaughat	1,400	E	800	29,764	23.81		
	9	10	600	B	300	10,289	3.09		
	14	Gaughat	600	D	1,350	17,649	23.83		
			Sub-Total		3,150		63.08	0.00	63.08
Construct New Trunk Sewer									
	4	5	600	B	900	13,718	12.35		
	5	7	900	C	1,250	19,986	24.98		
	8	Gaughat	600	C	1,200	18,557	22.27		
			Sub-Total		3,350		59.60	0.00	59.60
Replace Old Sewer (150% of construct cost)									
	1	2	700	C	2,200	29,028		63.86	
	2	3	700	C	1,650	29,028		47.90	
	6	7	700	C	1,500	29,028	43.54		
	10	12	900	C	750	29,979	22.48		
	11	12	1,400	D	1,100	50,555	55.61		
	12	13	1,200	D	1,050	42,918	45.06		
	13	Gaughat	1,400	D	850	50,555	42.97		
			Sub-Total		5,250		209.66	111.76	321.42
			Total		11,750		332.34	111.76	444.10
District-B									
Trunk Sewer (From Lukerganj PS to STP)									
	Luker	3	1,200	C	1,300	23,768	30.90		
	3	Ghaghar	1,400	C	2,000	28,639	57.28		
			Sub-Total		3,300		88.18	0.00	88.18
Trunk Sewer (FSA-2)									
	2	3	500	B	1,400	12,368		17.32	
			Sub-Total		1,400		0.00	17.32	17.32
			Total		4,700		88.18	17.32	105.50
District C									
Trunk Sewer									
	1	2	700	C	600	19,352		11.61	
	2	3	900	D	750	24,697		18.52	
	3	4	1,200	C	2,000	23,768		47.54	
	4	5	1,400	E	2,600	39,685		103.18	
	5	Salori	1,400	D	2,000	33,703		67.41	
			Sub-Total		7,950		0.00	248.26	248.26
			Total		7,950		0.00	248.26	248.26

Depth

Symbol	Range
A	-1.5 m
B	1.5 - 3.0 m
C	3.0 - 4.5 m
D	4.5 -6.0 m
E	6.0 - 7.5 m
F	7.5 - 9.0 m
G	9.0 - 10.5m
H	10.5 - 12.0 m

Table 9.2 Preliminary Capital Cost Estimate: Trunk Sewers and Laterals (Page 2 of 2)

Base year : 2003
City: Allahabad

District	Node (US)	Node (DS)	Diameter (mm)	depth	length (m)	unit cost (Rs./m)	Cost (Rs. million) Stage I -2015	Stage II 2016-2030	Total
District D									
Pumping Area									
Rehabilitate Existing Sewer (75% of construct cost)									
	5	8	900	A	850	8,648	7.35		
	8	11	900	A	950	8,648	8.22		
	10	11	600	A	1,500	6,995	10.49		
	11	Alopiba	1,000	A	700	9,375	6.56		
			Sub-Total		4,000		32.62	0.00	32.62
Construct New Trunk Sewer									
	6	7	500	C	1,100	17,162	18.88		
	17	Mumfor	1,600	C	2,000	32,205	64.41		
	Mumfor	STP	1,800	C	1,500	38,454	57.68		
			Sub-Total		4,600		140.97	0.00	140.97
Replace Old Sewer (150% of construct cost)									
	7	8	500	B	1,200	18,552		22.26	
	9	11	600	C	1,500	27,836	41.75		
	13	15	700	B	400	21,725	8.69		
	15	Alopiba	1,000	C	900	31,494	28.34		
			Sub-Total		4,000		78.78	22.26	101.04
Gravity Sewer Area									
Construct New Trunk Sewer									
	1	2	500	B	1,600	12,368		19.79	
	2	4	700	C	850	19,352		16.45	
	3	4	500	B	2,000	12,368		24.74	
	4	Mumfor	800	B	1,100	15,637		17.20	
	19	STP	1,000	C	2,000	20,996		41.99	
			Sub-Total		7,550		0.00	120.17	120.17
			Total		20,150		252.37	142.43	394.80
District E									
Trunk Sewer									
	1	2	900	C	2,400	19,986		47.97	
	2	STP	1,000	E	2,000	31,293		62.59	
	3	5	900	B	1,650	15,431		25.46	
	4	5	700	C	2,250	19,352		43.54	
	5	STP	1,200	D	1,000	28,612		28.61	
			Sub-Total		3,250			208.17	208.17
			Total		3,250		0.00	208.17	208.17
District F									
Trunk Sewer									
	1	3	500	C	1,850	17,162		31.75	
	2	3	500	B	1,300	12,368		16.08	
	3	STP	700	C	500	19,352		9.68	
			Sub-Total		3,650			57.51	57.51
			Total		3,650		0.00	57.51	57.51
District G									
Trunk Sewer									
	1	2	600	B	900	13,718		12.35	
	2	4	800	D	800	25,594		20.48	
	3	4	800	C	1,100	20,541		22.60	
	4	5	1,400	F	400	46,120		18.45	
	5	STP	1,600	F	1,200	50,021		60.03	
			Sub-Total		4,400			133.91	133.91
			Total		4,400		0.00	133.91	133.91
Total									

Table 9.3 Preliminary Capital Cost Estimate: Branch Sewers

Base year : 2003
City: Allahabad

District/Zone	Area (ha)	Length (m) Stage I -2015	Length (m) Stage II 2016-2030	Cost (Rs. million) Stage I -2015	Cost (Rs. million) Stage II 2016-2030	Cost (Rs. million) Total
District A						
Zone A	1,321	76,288	178,005	76.29	178.01	254.30
Sub-Total	1,321			76.29	178.01	254.30
District B						
Zone B (B-1)	384	29,568	59,136	29.56	59.14	88.70
Zone B (B-2)	416	64,064	96,096	64.06	96.10	160.16
FSA 2	75	0	28,875	-	28.88	28.88
Sub-Total	875			93.62	184.12	277.74
District C						
Zone C	647	0	249,095	-	249.10	249.10
Sub-Total	647			-	249.10	249.10
District D						
Zone D1 (Pumping)	886	51,167	153,500	51.17	153.50	204.67
Zone D2 (Gravity)	823	0	316,855	-	316.86	316.86
Sub-Total	1,709			51.17	470.36	521.53
District E						
Zone E	928	0	357,280	-	357.28	357.28
Sub-Total	928			-	357.28	357.28
District F						
Zone F	186	0	71,610	-	71.61	71.61
Sub-Total	186			-	71.61	71.61
District G						
Zone G	867	0	233,657	-	233.66	233.66
FSA 1	515	0	198,275	-	198.28	198.28
Sub-Total	1,382			-	431.94	431.94
Total	7,048			221.08	1,942.42	2,163.50

1. Average length of branch sewer per hectare taken as 385 m / ha.
2. A factor of increment in connection target in each Phase, has been used for calculation of lengths of branch sewers.
   Branch sewer length = 385 x Area (ha) x Increment in connection target (%)
3. Cost per unit length taken as Rs. 1000 / m (Jal Sansthan, Allahabad) assuming 250 mm diameter concrete pipe.

Existing and proposed branch sewer coverage

District/Zone	Year 2003	2010	2015	2030
District A				
Zone A	50%	55%	65%	100%
District B				
Zone B (B-1)	40%	50%	60%	100%
Zone B (B-2)	0%	0%	40%	100%
FSA 2	0%	0%	0%	100%
District C				
Zone C	0%	0%	0%	100%
District D				
Zone D1 (Pumping)	40%	45%	55%	100%
Zone D2 (Gravity)	0%	0%	0%	100%
District E				
Zone E	0%	0%	0%	100%
District F				
Zone F	0%	0%	0%	100%
District G				
Zone G	30%	30%	30%	100%
FSA 1	0%	0%	0%	100%

Table 9.4 Preliminary Capital Cost Estimate: House Connections (Page 1 of 2)

Base year : 2003
City: Allahabad

District/Zone	No. of households with connection				Cost (Rs. Million)		
	2003	2010	2015	2030	Srage I -2015	Stage II 2016-2030	Total
District A							
Zone A	23,732	29,141	37,749	63,933	108.63	202.93	311.56
Sub-Total					108.63	202.93	311.56
District B							
Zone B (B-1)	3,490	5,902	8,492	18,733	38.77	79.37	118.13
Zone B (B-2)	0	0	2,581	11,382	20.00	68.21	88.21
FSA 2	0	0	0	3,217	0.00	24.93	24.93
Sub-Total					58.77	172.51	231.28
District C							
Zone C	0	0	0	28,691	0.00	222.36	222.36
Sub-Total					0.00	222.36	222.36
District D							
Zone D1 (Pumping)	7,635	10,260	14,433	33,189	52.68	145.36	198.04
Zone D2 (Gravity)	0	0	0	30,610	0.00	237.23	237.23
Sub-Total					52.68	382.59	435.27
District E					0.00		
Zone E	0	0	0	20,546	0.00	159.23	159.23
Sub-Total					0.00	159.23	159.23
District F							
Zone F	0	0	0	4,476	0.00	34.69	34.69
Sub-Total					0.00	34.69	34.69
District G							
Zone G	0	0	0	18,870	0.00	146.24	146.24
FSA 1	0	0	0	9,396	0.00	72.82	72.82
Sub-Total					0.00	219.06	219.06
Total					220.08	1,393.36	1,613.44

1. Unit cost per connection taken as Rs. 7750
2. Existing and proposed connection targets (%) have been used to calculate the Number of households with connection.
Cost = Rs. 7750 x Increase in Number of households with connection.

Population and number of households

Zone	No. of persons per household	2003		Stage I				StageII	
				Before 2010		2011-2015		2016-2030	
		Population	Total Households	Population	Total Households	Population	Total Households	Population	Total Households
District A									
Zone A	6.3	373,770	59,329	407,969	64,757	432,397	68,634	503,469	79,916
District B									
Zone B (B-1)	6.3	73,285	11,633	92,949	14,754	106,995	16,983	147,523	23,416
Zone B (B-2)	6.3	33,612	5,335	45,622	7,242	54,201	8,603	89,633	14,227
FSA 2	6.3	13,099	2,079	17,321	2,749	20,337	3,228	25,332	4,021
District C	6.3								
Zone C	6.3	113,184	17,966	139,743	22,181	158,714	25,193	225,944	35,864
District D									
Zone D1 (Pumping)	6.3	160,332	25,450	184,676	29,314	202,064	32,074	261,363	41,486
Zone D2 (Gravity)	6.3	114,480	18,171	142,425	22,607	162,385	25,775	241,051	38,262
District E									
Zone E	6.3	96,858	15,374	130,085	20,648	153,819	24,416	258,872	41,091
District F									
Zone F	6.3	21,321	3,384	30,416	4,828	36,913	5,859	56,394	8,951
District G									
Zone G	6.3	62,981	9,997	82,987	13,173	97,277	15,441	148,600	23,587
FSA 1	6.3	38,283	6,077	54,058	8,581	65,325	10,369	118,389	18,792

1. No. of persons per household, for the city of Allahabad has been taken as 6.3.
2. Population considered here is the total population i.e. Resident + Floating.

Table 9.4 Preliminary Capital Cost Estimate: House Connections (Page 2 of 2)

Base year : 2003
City: Allahabad

Existing and proposed household connection targets

District/Zone	Year			
	2003	2010	2015	2030
District A				
Zone A	40%	45%	55%	80%
District B				
Zone B (B-1)	30%	40%	50%	80%
Zone B (B-2)	0%	0%	30%	80%
FSA 2	0%	0%	0%	80%
District C				
Zone C	0%	0%	0%	80%
District D				
Zone D1 (Pumping)	30%	35%	45%	80%
Zone D2 (Gravity)	0%	0%	0%	80%
District E				
Zone E	0%	0%	0%	50%
District F				
Zone F	0%	0%	0%	50%
District G				
Zone G	0%	0%	0%	80%
FSA 1	0%	0%	0%	50%

Table 9.5 Preliminary Capital Cost Estimate: Pumping Stations

Base year : 2003
City: Allahabad

Name	District	Status		Type of Pump	Design capacity Average flow (mld)		Cost (Rs. million)								
					Stage I	Stage II	Electrical service	M&E (Stage I)	Station piping and valves	M&E (Stage II)	Civil works	Misc. Road, wall, staff quarters	Total capital cost Stage I	Total capital cost Stage II	Total
					-2015	2016-2030			10% of M/E			10% of civil	-2015	2016-2030	
New pumping stations															
Ghaghar Nala SPS	B	P	Tap nala	Centrifugal	46.4	47.1	117.8	16.4		16.6	23.3	2.3	159.8	16.6	176.4
Upgrade Exisiting															
Chachar Nala SPS	A	E	Increase capacity of sump								4.6		4.6		4.6
	A	E	Replace pumps	Centrifugal		12.0				8.0				8.0	8.0
Gaughat MPS	A	E	Replace pump	Centrifugal		74.4				23.3				23.3	23.3
Lukerganj SPS	B	E	Reconstruct new	Centrifugal	9.4	18.3	45.8	7.3		9.5	4.4	0.4	57.9	9.5	67.4
Daraganj SPS	D	E	Replace pump			4.2				6.0				6.0	6.0
Allarpur SPS	D	E	Replace pump			5.5				6.4				6.4	6.4
Morigate Nala SPS	D	E	Reconstruct new	Centrifugal	30.0	12.1	30.3	12.4		8.0	11.1	1.1	54.8	8.0	62.8
Alopibagh SPS	D	E	Increase capacity of sump								3.3		3.3		3.3
			Replace pump			44.5				16.0			-	16.0	16.0
Mumfordganj MPS	D	E	Reconstruct new	Centrifugal	50.0	61.4	153.5	17.3		20.1	24.9	2.5	198.2	20.1	218.3
Total													478.6	113.9	592.5

Type of pump	Costs (Rs. million)		
	M&E	Civil	Electrical Service
Centrifugal (>=30mld)	Y = 0.2462x + 5.0009	Y=26.958Ln(x) - 80.598	Y= 2.5x
Submersible (<30mld)	Y = 0.3x	Y = 0.1679x + 1.3616	Y = 0.8x

	Stage I	Stage II	Total
	-2015	2016-2030	
District A	4.6	31.3	35.9
District B	217.7	26.1	243.8
District C	0.0	0.0	0.0
District D	256.3	56.5	312.8
District E	0.0	0.0	0.0
District F	0.0	0.0	0.0
District G	0.0	0.0	0.0
Total	478.6	113.9	592.5

Table 9.6 Preliminary Capital Cost Estimate: Rising Mains

Base year : 2003
City: Allahabad

District	Pump station	Diameter (mm)	length (m)	Type of material	Unit Cost (Rs./m)	Cost (Rs. million)		
						Stage I	Stage II	Total
District A	Gaughat MPS	914/686	1,500	CIP		Exisiting		
	Sub-Total					0.00	0.00	0.00
District B	Lukarganj PS	400	30	DIP	6,362	0.19		
	Ghaghar Nala PS	1,000	10,000	PSC	13,806	138.06		
	Sub-Total					138.25	0.00	138.25
District C								
	Sub-Total					0.00	0.00	0.00
District D	Daraganj PS	356	700	PSC		Exisiting		
	Allarpur PS	700	250	PSC		Exisiting		
	Morigate PS	500	1,950	DIP		Exisiting		
		700	1,950	DIP	9,454	18.44		
	Alopibagh PS	1,000	2,500	PSC	13,806	34.52		
	Mumfortganj PS	1,000	2,000	DIP	13,806	27.61		
	Sub-Total					80.57	0.00	80.57
District E								
	Sub-Total					0.00	0.00	0.00
District F								
	Sub-Total					0.00	0.00	0.00
District G								
	Sub-Total					0.00	0.00	0.00
Total						218.82	0.00	218.82

Table 9.7 Preliminary Capital Cost Estimate: Treatment Plants

Base year : 2003
City: Allahabad

	District	Process	Unit Cost Rs 10^6/mld	Status	Incremental Capacity (mld)		Civil Cost (Rs. million)		M&E Cost (Rs. million)		Total Cost (Rs. million)		
					Stage I	Stage II	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II	Total
					-2015	2016-2030	-2015	2016-2030	-2015	2016-2030	-2015	2016-2030	
Naini STP	A	ASP	2.7	E	(60 mld)						Existing		
		ASP	2.7	A	20.0		32.4		21.6		54.0	0.0	54.0
Numaya Dahi STP	B	WSP	1.6	P	50.0		78.4		1.6		80.0	0.0	80.0
Salori STP	C	FAB	4.6	S	(29 mld)						Sanctioned		
		FAB	4.6	A		6.0		11.0		16.6	0.0	27.6	27.6
Rajapur STP	D	UASB++	3.0	P	65.0	15.0	136.5	31.5	58.5	13.5	195.0	45.0	240.0
Kodara STP	E	UASB++	3.0	P	15.0	15.0	31.5	31.5	13.5	13.5	45.0	45.0	90.0
Ponghat STP	E	WSP	1.6	P	10.0		15.7		0.3		16.0	0.0	16.0
Phaphamau STP	F	WSP	1.6	P		10.0		15.7		0.3	0.0	16.0	16.0
Mawaiya STP	G	UASB++	3.0	P		45.0		94.5		40.5	0.0	135.0	135.0
Total							294.5	184.2	95.5	84.4	390.0	268.6	658.6
Saanctioned facility									**(Replace)**				
Salori STP		FAB	4.6	S	29.0		53.4		80.0		133.4		

Cost of banking for Rajapur STP, District D

Volume of banking	860,000	(m3)
Unit cost of banking	500	(Rs./m3)
Cost of banking	430	(Million Rs.)

Table 9.8 Preliminary Capital Cost Estimate: Land Acquisition

Base year : 2003
City: Allahabad

(1) Treatment Plant

	District	Process	Land Req. (ha/MLD)	Status	Ultimate Capacity (mld)		Land Requirement (ha)		Cost (Rs. million)		
					Stage I	Stage II	Stage I	Stage II	Stage I	Stage II	Total
					-2015	2016-2030	Before 2010	2016-2030	Before 2010	2016-2030	
Naini STP	A	AS	0.20	E	80.0				Existing		0.0
Numaya Dahi STP	B	WSP	1.25	P	55.0		68.8		275.2		275.2
Salori STP	C	FAB	0.06	S	29.0				Sanctioned		0.0
Rajapur STP	D	UASB++	0.35	P	80.0		28.0		112.0		112.0
			(banking)				6.0		24.0		24.0
Kodara STP	E	UASB++	0.35	P	30.0		10.5		42.0		42.0
Ponghat STP	E	WSP	1.25	P	10.0		12.5		50.0		50.0
Phaphamau STP	F	WSP	1.25	P		10.0		12.5		50.0	50.0
Mawaiya STP	G	UASB++	0.35	P		45.0		15.8		63.2	63.2
Total							125.8	28.3	503.2	113.2	616.4

(2) Pumping Station

	District		Status		Land Requirement (ha)		Cost (Rs. million)		
					Stage I	Stage II	Stage I	Stage II	Total
					Before 2010	2016-2030	Before 2010	2016-2030	
Ghaghar Nala SPS	B		P		1.0		4.0		4.0
Total							4.0	0.0	4.0

	Stage I	Stage II	Total
	Before 2010	2016-2030	
District A	0.0	0.0	0.0
District B	279.2	0.0	279.2
District C	0.0	0.0	0.0
District D	136.0	0.0	136.0
District E	92.0	0.0	92.0
District F	0.0	50.0	50.0
District G	0.0	63.2	63.2
Total	507.2	113.2	620.4

Table 9.9 Replacement Cost of Existing Assets

Treatment Plant (Millon Rs.)

	District	Capacity (mld)	Type	Capital cost	
				Civil	M/E
Naini STP	A	80.0	ASP	129.60	86.40
Sub-Total				-	86.40

Table 9.10 Annual Operation and Maintenance Costs: Summary

(Rs. million)

	Status	District	Stage I				Stage II			
			Maintenance	Staff	Energy	Total	Maintenance	Staff	Energy	Total
Sewer Maintenance										
District A			6.63	0.30	-	6.93	9.53	0.30	-	9.83
District B			2.24	0.30	-	2.54	4.25	0.30	-	4.55
District C			-	-	-	-	4.97	0.30	-	5.27
District D			4.40	0.30	-	4.70	10.53	0.30	-	10.83
District E			-	-	-	-	5.65	0.15	-	5.80
District F			-	-	-	-	1.29	0.15	-	1.44
District G			-	-	-	-	6.66	0.30	-	6.96
Sub-total sewers			13.27	0.90	-	14.17	42.88	1.80	-	44.68
Pump stations										
Chachar Nala SPS	E	A	0.32	0.53	1.05	1.90	0.32	0.53	0.48	1.32
Gaughat MPS	E	A	1.35	0.69	1.57	3.60	1.35	0.69	1.95	3.99
Lukerganj SPS	E	B	0.29	0.47	0.29	1.05	0.29	0.47	0.61	1.36
Ghaghar Nala MPS	P	B	1.19	0.69	2.16	4.04	1.19	0.69	2.33	4.21
Daraganj SPS	E	D	0.06	0.47	0.09	0.62	0.06	0.47	0.16	0.70
Allahpur	E	D	0.07	0.47	0.10	0.64	0.07	0.47	0.10	0.64
Morigate Nala SPS	E	D	0.46	0.47	1.34	2.28	0.46	0.47	0.38	1.31
Alopibagh SPS	E	D	0.90	0.53	2.21	3.64	0.90	0.53	1.85	3.28
Mumfordganj	E	D	1.04	0.47	1.53	3.05	1.04	0.47	2.10	3.61
Sub-total pumping stations			5.67	4.79	10.34	20.81	5.67	4.79	9.97	20.43
Treatment plants										
Naini STP	E	A	4.54	7.22	18.10	29.86	4.54	7.22	18.10	29.86
Numaya Dahi STP	P	B	1.22	3.76	0.00	4.98	1.22	3.76	0.00	4.98
Salori STP	P	C	3.20	4.72	5.58	13.50	3.86	4.72	6.73	15.32
Rajapur STP	P	D	3.80	5.05	5.44	14.30	4.68	7.22	6.70	18.60
Kodara STP	P	E	0.88	3.83	1.26	5.96	1.76	4.72	2.51	8.99
Ponghat Nala STP	P	E	0.31	2.31	0.00	2.62	0.31	2.31	0.00	2.62
Phaphamau STP	P	F					0.24	2.31	0.00	2.55
Mawaiya STP	P	G					2.63	4.72	3.77	11.12
Sub-total treatment plants			13.95	26.89	30.38	71.22	19.25	36.98	37.81	94.04
Total			32.90	32.58	40.72	106.20	67.80	43.57	47.78	159.16

Table 9.12 Annual Operation and Maintenance: Pumping Stations

(Rs. million)

	Status	District	Stage I						Stage II					
			Annual Repair Cost			Staff	Energy	Total	Annual Repair Cost			Staff	Energy	Total
			M&E 3%	Rising Main 0.25%	Civil works 1.5%				M&E 3%	Rising Main 0.25%	Civil works 1.5%			
New pumping stations														
Ghaghar Nala MPS	P	B	0.49	0.35	0.35	0.69	2.16	4.04	0.50	0.35	0.35	0.69	2.33	4.22
Upgrade Exisiting														
Alopibagh SPS	E	D	0.49	0.09	0.33	0.53	2.21	3.64	0.48	0.09	0.33	0.53	1.85	3.27
Daraganj SPS	E	D	0.02	0.01	0.03	0.47	0.09	0.62	0.04	0.01	0.03	0.47	0.16	0.72
Lukerganj SPS	P	D	0.22	0.00	0.07	0.47	0.29	1.05	0.29	0.00	0.07	0.47	0.61	1.43
Morigate Nala SPS	P	D	0.37	0.04	0.05	0.47	1.34	2.28	0.24	0.04	0.05	0.47	0.38	1.18
Existing pump stations														
Chachar Nala SPS	E	A	0.23	0.03	0.05	0.53	1.05	1.90	0.11	0.03	0.05	0.53	0.48	1.20
Gaughat MPS	E	A	0.65	0.17	0.53	0.69	1.57	3.60	0.70	0.17	0.53	0.69	1.95	4.04
Allahpur SPS	E	D	0.03	0.01	0.03	0.47	0.10	0.64	0.05	0.01	0.03	0.47	0.21	0.77
Mumfordganj SPS	E	D	0.52	0.06	0.46	0.47	1.53	3.05	0.60	0.06	0.46	1.53	2.10	4.76
Total			3.02	0.75	1.90	4.79	10.34	20.81	3.00	0.75	1.90	5.86	10.07	21.58

Table 9.13 Annual Operation and Maintenance: Treatment Plants

(Rs. million)

	District	Process	Stage I					Stage II				
			Annual Repairs		Staff	Energy	Total	Annual Repairs		Staff	Energy	Total
			M&E 3%	Civil works 1.5%				M&E 3%	Civil works 1.5%			
Naini STP	A	AS	2.59	1.94	7.22	18.10	29.86	2.59	1.94	7.22	18.10	29.86
Numaya Dahi STP	B	WSP	0.05	1.18	3.76	0.00	4.98	0.05	1.18	3.76	0.00	4.98
Salori STP	C	FAB	2.40	0.80	4.72	5.58	13.50	2.90	0.97	4.72	6.73	15.32
Rajapur STP	D	UASB++	1.76	2.05	5.05	5.44	14.30	2.16	2.52	7.22	6.70	18.60
Kodara STP	E	UASB++	0.41	0.47	3.83	1.26	5.96	0.81	0.95	4.72	2.51	8.99
Ponghat STP	E	WSP	0.14	0.17	2.31	-	2.62	0.14	0.17	2.31	0.00	2.62
Phaphamau STP	F	WSP						0.01	0.24	2.31	0.00	2.55
Mawaiya STP	G	UASB++						1.22	1.42	4.72	3.77	11.12
Total			7.35	6.61	26.89	30.38	71.22	9.88	9.37	36.98	37.81	94.04

Energy Cost

	District	Process	kWhr/mld	Stage I		Stage II	
				mld	kWhr/day	mld	kWhr/day
Naini STP	A	AS	200	80	16,000	80	16,000
Numaya Dahi STP	B	WSP	0	35	0	45	0
Salori STP	C	FAB	170	29	4,930	35	5,950
Rajapur STP	D	UASB++	74	65	4,810	80	5,920
Kodara STP	E	UASB++	74	15	1,110	30	2,220
Ponghat STP	E	WSP	0	10	0	10	0
Phaphamau STP	F	WSP	0	0	0	10	0
Mawaiya STP	G	UASB++	74	0	0	45	3,330

Cost of electricity (Rs./kWhr):	3.1

Initial Cost for Calculating Maintenance Cost

(Rs. million)

	District	Process	Unit Cost Rs 10^6/mld	Capacity (mld)		Civil Cost		M&E Cost		Total Cost	
				Stage I -2015	Stage II 2016-2030	Stage I -2015	Stage II 2016-2030	Stage I -2015	Stage II 2016-2030	Stage I -2015	Stage II 2016-2030
Naini STP	A	ASP	2.7	80.0	80.0	129.6	129.6	86.4	86.4	216.0	216.0
Numaya Dahi STP	B	WSP	1.6	50.0	50.0	78.4	78.4	1.6	1.6	80.0	80.0
Salori STP	C	FAB	4.6	29.0	35.0	53.4	64.4	80.0	96.6	133.4	161.0
Rajapur STP	D	UASB++	3.0	65.0	80.0	136.5	168.0	58.5	72.0	195.0	240.0
Kodara STP	E	UASB++	3.0	15.0	30.0	31.5	63.0	13.5	27.0	45.0	90.0
Ponghat STP	E	WSP	1.6	10.0	10.0	11.2	11.2	4.8	4.8	16.0	16.0
Phaphamau STP	F	WSP	1.6		10.0		15.7		0.3	0.0	16.0
Mawaiya STP	G	UASB++	3.0		45.0		94.5		40.5	0.0	135.0
Total						440.6	624.8	244.8	329.2	685.4	954.0

Capacity includes existing facilities and sanctioned facilities

Table 9.14 Staff Requirements for Sewer Cleaning

Staff	No. Required	Unit Salaries/Month	Stage I		Stage II	
			Number of Crews	Annual Cost (Rs.)	Number of Crews	Annual Cost (Rs.)
Supervisor	1	5,500	4	264,000	6	396,000
Sewer inspector	1	4,500	4	216,000	6	324,000
Machine Operator	2	3,600	4	172,800	6	259,200
Helper	2	2,700	4	129,600	6	194,400
Sweeper	1	2,700	4	129,600	6	194,400
Unskilled laborer	3	2,700	4	129,600	6	194,400
Mason	1	3,300	4	158,400	6	237,600
Total				1,200,000		1,800,000

District-wise Staff Cost

	No. of Crews		Staff Cost	
	Stage I	Stage II	Stage I	Stage II
District A	1	1	300,000	300,000
District B	1	1	300,000	300,000
District C	1	1	300,000	300,000
District D	1	1	300,000	300,000
District E	0	0.5	0	150,000
District F	0	0.5	0	150,000
District G	0	1	0	300,000
Total	4	6	1,200,000	1,800,000

Capital Cost of Trunk Sewer (Rs. million)

	Capital Cost	
	Stage I	Stage II
District A	332.34	444.10
District B	70.99	88.31
District C	0.00	248.26
District D	252.37	394.80
District E	0.00	208.17
District F	0.00	57.51
District G	0.00	133.91
Total	655.70	1,575.06

Capital Cost of Branch Sewer (Rs. million)

	Area (ha)	Branch Cover Area (ha)		Length per ha (m/ha)	Branch Length (m)		Capital Cost	
		Stage I	Stage II		Stage I	Stage II	Stage I	Stage II
District A	1,321	859	1,321	385	330,715	508,585	330.72	508.59
District B	875	397	875	385	152,845	336,875	152.85	336.88
District C	647	0	647	385	0	249,095	0.00	249.10
District D	1,709	487	1,709	385	187,495	657,965	187.50	657.97
District E	928	0	928	385	0	357,280	0.00	357.28
District F	186	0	186	385	0	71,610	0.00	71.61
District G	1,382	0	1,382	385	0	532,070	0.00	532.07
Total	7,048	1,743	7,048		671,055	2,713,480	671.06	2,713.48

	Maintenance Cost	
	Stage I	Stage II
District A	6.63	9.53
District B	2.24	4.25
District C	0.00	4.97
District D	4.40	10.53
District E	0.00	5.65
District F	0.00	1.29
District G	0.00	6.66
Total	13.27	42.88

Maintenance Cost = 1.0% of Capital Cost

Table 9.15 Operation and maintenance staff: Requirements at Pumping Stations

Required Staff

S. No.	Post	Shifts	Ghaghar Nala	Lukerganj	Morigate	Allahpur	Allopibagh	Daraganj	Gaughat	Chachar nala	Mumfordganj
1	Junior Engineer	1	1.00	0.25	0.50	0.50	0.50	0.50	1.00	0.50	1.00
2	Electician	1	1.50	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.50
3	Mech. cum fitter	1	1.50	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.50
4	Pump Operator	3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	Beldar	2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	Sweeper	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Annual Staffing Costs (in Rs.)

S. No.	Post	Ghaghar Nala	Lukerganj	Morigate	Allahpur	Allopibagh	Daraganj	Gaughat	Chachar nala	Mumfordganj
1	Junior Engineer	224,400	56,100	112,200	112,200	112,200	112,200	224,400	112,200	224,400
2	Electrician	71,280	47,520	47,520	47,520	47,520	47,520	71,280	47,520	71,280
3	Mech. cum fitter	71,280	47,520	47,520	47,520	47,520	47,520	71,280	47,520	71,280
4	Pump Operator	213,840	213,840	213,840	213,840	213,840	213,840	213,840	213,840	213,840
5	Beldar	71,280	71,280	71,280	71,280	71,280	71,280	71,280	71,280	71,280
6	Sweeper	35,640	35,640	35,640	35,640	35,640	35,640	35,640	35,640	35,640
	TOTAL	687,720	471,900	528,000	528,000	528,000	528,000	687,720	528,000	687,720

Table 9.16 Operation and Maintenance Staff: requirements for Naini STP

Activated sludge

S. No.	Designation	Staff Requirement		Monthly Salary in Rs.	Annual wages in Rs.	
		Stage I	Stage II		Stage I	Stage II
1	Executive Engineer (Project Manager)	1	1	27,500	330,000	330,000
2	Assistant Engineer (E&M) (Asstt. Manager)	1	1	24,200	290,400	290,400
3	Assistant Engineer (Civil)	0	0	24,200	0	0
4	Junior Engineer (E&M) (Junior Manager)	6	6	19,800	1,425,600	1,425,600
5	Junior Engineer (Civil) (Junior Manager)	1	1	19,800	237,600	237,600
6	Fitter (Mech.) I Class	2	2	3,960	95,040	95,040
7	Electrician I Class	2	2	3,960	95,040	95,040
8	Fitter II Class	1	1	3,630	43,560	43,560
9	Electrician II Class	2	2	3,630	87,120	87,120
10	Gardener	2	2	3,080	73,920	73,920
11	Driver	1	1	7,700	92,400	92,400
12	Cleaner	1	1	3,080	36,960	36,960
13	Junior Accountant	1	1	11,550	138,600	138,600
14	UDC (Senior Assistant)	1	1	9,570	114,840	114,840
15	LDC/Typist (Junior Assistant)	2	2	8,360	200,640	200,640
16	Peon	2	2	6,050	145,200	145,200
17	Junior Stenographer	1	1	9,570	114,840	114,840
18	Chemist	1	1	7,700	92,400	92,400
19	Assistant Chemist	1	1	6,600	79,200	79,200
20	Lab Assistant	1	1	4,950	59,400	59,400
21	Lab Attendant	2	2	3,080	73,920	73,920
22	Sweeper	2	2	2,970	71,280	71,280
23	Weldar-cum-black smith	1	1	3,630	43,560	43,560
24	Operator	19	19	5,940	1,354,320	1,354,320
25	Labour (Beldar)	54	54	2,970	1,924,560	1,924,560
	TOTAL	108	108		7,220,400	7,220,400

Table 9.17 Operation and Maintenance Staff: requirements for Numaya Dahi STP

Waste stabilization pond

S. No.	Designation	Staff Requirement		Monthly Salary in Rs.	Annual wages in Rs.	
		Stage I	Stage II		Stage I	Stage II
1	Executive Engineer (Project Manager)	0	0	27,500	0	0
2	Assistant Engineer (E&M) (Asstt. Manager)	1	1	24,200	290,400	290,400
3	Assistant Engineer (Civil)	0	0	24,200	0	0
4	Junior Engineer (E&M) (Junior Manager)	1	1	19,800	237,600	237,600
5	Junior Engineer (Civil) (Junior Manager)	4	4	19,800	950,400	950,400
6	Fitter (Mech.) I Class	1	1	3,960	47,520	47,520
7	Electrician I Class	1	1	3,960	47,520	47,520
8	Fitter II Class	0.5	0.5	3,630	21,780	21,780
9	Electrician II Class	1	1	3,630	43,560	43,560
10	Gardener	2	2	3,080	73,920	73,920
11	Driver	1	1	7,700	92,400	92,400
12	Cleaner	1	1	3,080	36,960	36,960
13	Junior Accountant	1	1	11,550	138,600	138,600
14	UDC (Senior Assistant)	1	1	9,570	114,840	114,840
15	LDC/Typist (Junior Assistant)	1	1	8,360	100,320	100,320
16	Peon	1	1	6,050	72,600	72,600
17	Junior Stenographer	0	0	9,570	0	0
18	Chemist	0	0	7,700	0	0
19	Assistant Chemist	1	1	6,600	79,200	79,200
20	Lab Assistant	1	1	4,950	59,400	59,400
21	Lab Attendant	1	1	3,080	36,960	36,960
22	Sweeper	2	2	2,970	71,280	71,280
23	Weldar-cum-black smith	0	0	3,630	0	0
24	Operator	4	4	5,940	285,120	285,120
25	Labour (Beldar)	27	27	2,970	962,280	962,280
	TOTAL	53.5	53.5		3,762,660	3,762,660

Table 9.18 Operation and Maintenance Staff: requirements for Salori STP

FAB Technology

S. No.	Designation	Staff Requirement		Monthly Salary in Rs.	Annual wages in Rs.	
		Stage I	Stage II		Stage I	Stage II
1	Executive Engineer (Project Manager)	0	0	27,500	0	0
2	Assistant Engineer (E&M) (Asstt. Manager)	1	1	24,200	290,400	290,400
3	Assistant Engineer (Civil)	0	0	24,200	0	0
4	Junior Engineer (E&M) (Junior Manager)	4	4	19,800	950,400	950,400
5	Junior Engineer (Civil) (Junior Manager)	0	0	19,800	0	0
6	Fitter (Mech.) I Class	1	1	3,960	47,520	47,520
7	Electrician I Class	1	1	3,960	47,520	47,520
8	Fitter II Class	0	0	3,630	0	0
9	Electrician II Class	1	1	3,630	43,560	43,560
10	Gardener	1	1	3,080	36,960	36,960
11	Driver	0	0	7,700	0	0
12	Cleaner	0	0	3,080	0	0
13	Junior Accountant	1	1	11,550	138,600	138,600
14	UDC (Senior Assistant)	1	1	9,570	114,840	114,840
15	LDC/Typist (Junior Assistant)	1	1	8,360	100,320	100,320
16	Peon	1	1	6,050	72,600	72,600
17	Junior Stenographer	0	0	9,570	0	0
18	Chemist	0	0	7,700	0	0
19	Assistant Chemist	0	0	6,600	0	0
20	Lab Assistant	1	1	4,950	59,400	59,400
21	Lab Attendant	2	2	3,080	73,920	73,920
22	Sweeper	1	1	2,970	35,640	35,640
23	Weldar-cum-black smith	0	0	3,630	0	0
24	Operator	16	16	5,940	1,140,480	1,140,480
25	Labour (Beldar)	44	44	2,970	1,568,160	1,568,160
	TOTAL	77	77		4,720,320	4,720,320

Table 9.19 Operation and Maintenance Staff: requirements for Rajapur STP

UASB + Aerated lagoons

S. No.	Designation	Staff Requirement		Monthly Salary in Rs.	Annual wages in Rs.	
		Stage I	Stage II		Stage I	Stage II
1	Executive Engineer (Project Manager)	1	1	27,500	330,000	330,000
2	Assistant Engineer (E&M) (Asstt. Manager)	1	1	24,200	290,400	290,400
3	Assistant Engineer (Civil)	0	0	24,200	0	0
4	Junior Engineer (E&M) (Junior Manager)	4	6	19,800	950,400	1,425,600
5	Junior Engineer (Civil) (Junior Manager)	0	1	19,800	0	237,600
6	Fitter (Mech.) I Class	1	2	3,960	47,520	95,040
7	Electrician I Class	1	2	3,960	47,520	95,040
8	Fitter II Class	0	1	3,630	0	43,560
9	Electrician II Class	1	2	3,630	43,560	87,120
10	Gardener	1	2	3,080	36,960	73,920
11	Driver	0	1	7,700	0	92,400
12	Cleaner	0	1	3,080	0	36,960
13	Junior Accountant	1	1	11,550	138,600	138,600
14	UDC (Senior Assistant)	1	1	9,570	114,840	114,840
15	LDC/Typist (Junior Assistant)	1	2	8,360	100,320	200,640
16	Peon	1	2	6,050	72,600	145,200
17	Junior Stenographer	0	1	9,570	0	114,840
18	Chemist	0	1	7,700	0	92,400
19	Assistant Chemist	0	1	6,600	0	79,200
20	Lab Assistant	1	1	4,950	59,400	59,400
21	Lab Attendant	2	2	3,080	73,920	73,920
22	Sweeper	1	2	2,970	35,640	71,280
23	Welder-cum-black smith	0	1	3,630	0	43,560
24	Operator	16	19	5,940	1,140,480	1,354,320
25	Labour (Beldar)	44	54	2,970	1,568,160	1,924,560
	TOTAL	78	108		5,050,320	7,220,400

Table 9.20 Operation and Maintenance Staff: requirements for Kodara STP

UASB + Aerated lagoon

S. No.	Designation	Staff Requirement		Monthly Salary in Rs.	Annual wages in Rs.	
		Stage I	Stage II		Stage I	Stage II
1	Executive Engineer (Project Manager)	0	0	27,500	0	0
2	Assistant Engineer (E&M) (Asstt. Manager)	1	1	24,200	290,400	290,400
3	Assistant Engineer (Civil)	0	0	24,200	0	0
4	Junior Engineer (E&M) (Junior Manager)	4	4	19,800	950,400	950,400
5	Junior Engineer (Civil) (Junior Manager)	0	0	19,800	0	0
6	Fitter (Mech.) I Class	1	1	3,960	47,520	47,520
7	Electrician I Class	1	1	3,960	47,520	47,520
8	Fitter II Class	0	0	3,630	0	0
9	Electrician II Class	1	1	3,630	43,560	43,560
10	Gardener	1	1	3,080	36,960	36,960
11	Driver	0	0	7,700	0	0
12	Cleaner	0	0	3,080	0	0
13	Junior Accountant	1	1	11,550	138,600	138,600
14	UDC (Senior Assistant)	1	1	9,570	114,840	114,840
15	LDC/Typist (Junior Assistant)	1	1	8,360	100,320	100,320
16	Peon	1	1	6,050	72,600	72,600
17	Junior Stenographer	0	0	9,570	0	0
18	Chemist	0	0	7,700	0	0
19	Assistant Chemist	0	0	6,600	0	0
20	Lab Assistant	1	1	4,950	59,400	59,400
21	Lab Attendant	1	2	3,080	36,960	73,920
22	Sweeper	1	1	2,970	35,640	35,640
23	Weldar-cum-black smith	0	0	3,630	0	0
24	Operator	12	16	5,940	855,360	1,140,480
25	Labour (Beldar)	28	44	2,970	997,920	1,568,160
	TOTAL	56	77		3,828,000	4,720,320

Table 9.21 Operation and Maintenance Staff: requirements for Ponghat STP

Waste stabilization pond

S. No.	Designation	Staff Requirement		Monthly Salary in Rs.	Annual wages in Rs.	
		Stage I	Stage II		Stage I	Stage II
1	Executive Engineer (Project Manager)	0	0	27,500	0	0
2	Assistant Engineer (E&M) (Asstt. Manager)	1	1	24,200	290,400	290,400
3	Assistant Engineer (Civil)	0	0	24,200	0	0
4	Junior Engineer (E&M) (Junior Manager)	1	1	19,800	237,600	237,600
5	Junior Engineer (Civil) (Junior Manager)	2	2	19,800	475,200	475,200
6	Fitter (Mech.) I Class	0	0	3,960	0	0
7	Electrician I Class	0.5	0.5	3,960	23,760	23,760
8	Fitter II Class	0.5	0.5	3,630	21,780	21,780
9	Electrician II Class	0.5	0.5	3,630	21,780	21,780
10	Gardener	1	1	3,080	36,960	36,960
11	Driver	0	0	7,700	0	0
12	Cleaner	0	0	3,080	0	0
13	Junior Accountant	1	1	11,550	138,600	138,600
14	UDC (Senior Assistant)	1	1	9,570	114,840	114,840
15	LDC/Typist (Junior Assistant)	1	1	8,360	100,320	100,320
16	Peon	1	1	6,050	72,600	72,600
17	Junior Stenographer	0	0	9,570	0	0
18	Chemist	0	0	7,700	0	0
19	Assistant Chemist	0	0	6,600	0	0
20	Lab Assistant	1	1	4,950	59,400	59,400
21	Lab Attendant	1	1	3,080	36,960	36,960
22	Sweeper	1	1	2,970	35,640	35,640
23	Weldar-cum-black smith	0	0	3,630	0	0
24	Operator	4	4	5,940	285,120	285,120
25	Labour (Beldar)	10	10	2,970	356,400	356,400
	TOTAL	27.5	27.5		2,307,360	2,307,360

Table 9.22 Operation and Maintenance Staff: requirements for Phaphamau STP

Waste stabilization pond

S. No.	Designation	Staff Requirement		Monthly Salary in Rs.	Annual wages in Rs.	
		Stage I	Stage II		Stage I	Stage II
1	Executive Engineer (Project Manager)	0	0	27,500	0	0
2	Assistant Engineer (E&M) (Asstt. Manager)	0	0.5	24,200	0	145,200
3	Assistant Engineer (Civil)	0	1	24,200	0	290,400
4	Junior Engineer (E&M) (Junior Manager)	0	1	19,800	0	237,600
5	Junior Engineer (Civil) (Junior Manager)	0	2	19,800	0	475,200
6	Fitter (Mech.) I Class	0	0	3,960	0	0
7	Electrician I Class	0	0	3,960	0	0
8	Fitter II Class	0	1	3,630	0	43,560
9	Electrician II Class	0	0	3,630	0	0
10	Gardener	0	1	3,080	0	36,960
11	Driver	0	0	7,700	0	0
12	Cleaner	0	0	3,080	0	0
13	Junior Accountant	0	1	11,550	0	138,600
14	UDC (Senior Assistant)	0	1	9,570	0	114,840
15	LDC/Typist (Junior Assistant)	0	1	8,360	0	100,320
16	Peon	0	1	6,050	0	72,600
17	Junior Stenographer	0	0	9,570	0	0
18	Chemist	0	0	7,700	0	0
19	Assistant Chemist	0	0	6,600	0	0
20	Lab Assistant	0	1	4,950	0	59,400
21	Lab Attendant	0	1	3,080	0	36,960
22	Sweeper	0	1	2,970	0	35,640
23	Weldar-cum-black smith	0	0	3,630	0	0
24	Operator	0	4	5,940	0	285,120
25	Labour (Beldar)	0	14	2,970	0	498,960
	TOTAL	0	31.5		0	2,571,360

Table 9.23 Operation and Maintenance Staff: requirements for Mawaiya STP

UASB + Aerated lagoon

S. No.	Designation	Staff Requirement		Monthly Salary in Rs.	Annual wages in Rs.	
		Stage I	Stage II		Stage I	Stage II
1	Executive Engineer (Project Manager)	0	0	27,500	0	0
2	Assistant Engineer (E&M) (Asstt. Manager)	0	1	24,200	0	290,400
3	Assistant Engineer (Civil)	0	0	24,200	0	0
4	Junior Engineer (E&M) (Junior Manager)	0	4	19,800	0	950,400
5	Junior Engineer (Civil) (Junior Manager)	0	0	19,800	0	0
6	Fitter (Mech.) I Class	0	1	3,960	0	47,520
7	Electrician I Class	0	1	3,960	0	47,520
8	Fitter II Class	0	0	3,630	0	0
9	Electrician II Class	0	1	3,630	0	43,560
10	Gardener	0	1	3,080	0	36,960
11	Driver	0	0	7,700	0	0
12	Cleaner	0	0	3,080	0	0
13	Junior Accountant	0	1	11,550	0	138,600
14	UDC (Senior Assistant)	0	1	9,570	0	114,840
15	LDC/Typist (Junior Assistant)	0	1	8,360	0	100,320
16	Peon	0	1	6,050	0	72,600
17	Junior Stenographer	0	0	9,570	0	0
18	Chemist	0	0	7,700	0	0
19	Assistant Chemist	0	0	6,600	0	0
20	Lab Assistant	0	1	4,950	0	59,400
21	Lab Attendant	0	2	3,080	0	73,920
22	Sweeper	0	1	2,970	0	35,640
23	Weldar-cum-black smith	0	0	3,630	0	0
24	Operator	0	16	5,940	0	1,140,480
25	Labour (Beldar)	0	44	2,970	0	1,568,160
	TOTAL	0	77		0	4,720,320

Staff suggested for Stage I and Stage II is for 45 MLD capacity.

Table 9.24.1 Implementation/Investment Schedule, District A (Page 1 of 2)

	Stage I											Stage II							
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Direct Construction Cost																			
Trunk Sewer				66.4	66.4	66.5	66.5	66.5				37.2	37.3	37.3					
Rising Main																			
Branch Sewer				9.5	9.5	9.5	9.5	9.5	9.6	9.6	9.6	11.8	11.8	11.8	11.8	11.8	11.9	11.9	11.9
Chachar Nala SPS				4.6															8.0
Gaughat MPS																			23.3
Naini STP				18.0	36.0														86.4
Sub Total of Direct Cost	0.0	0.0	0.0	98.5	111.9	76.0	76.0	76.0	9.6	9.6	9.6	49.0	49.1	49.1	11.8	11.8	11.9	11.9	129.6
O/M Cost																			
Sewers				6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
Chachar Nala SPS	1.5	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Gaughat MPS	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Naini STP	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9
Sub Total of O/M Cost	34.7	35.1	35.1	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7
Sum of Direct Cost and O/M Cost	34.7	35.1	35.1	140.5	153.9	118.0	118.0	118.0	51.6	51.6	51.6	93.7	93.8	93.8	56.5	56.5	56.6	56.6	174.3
House Connection																			
District A				13.5	13.5	13.6	13.6	13.6	13.6	13.6	13.6	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Sub Total of House Connection				13.5	13.5	13.6	13.6	13.6	13.6	13.6	13.6	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Land Acquisition																			
District A																			
Sub Total of Land Acquisition				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub Total				154.0	167.4	131.6	131.6	131.6	65.2	65.2	65.2	107.2	107.3	107.3	70.0	70.0	70.1	70.1	187.8

Table 9.24.1 Implementation/Investment Schedule, District A (Page 2 of 2)

	Stage II							Total
	2024	2025	2026	2027	2028	2029	2030	
Direct Construction Cost								
Trunk Sewer								444.1
Rising Main								0.0
Branch Sewer	11.9	11.9	11.9	11.9	11.9	11.9	11.9	254.3
Chachar Nala SPS								12.6
Gaughat MPS								23.3
Naini STP								140.4
Sub Total of Direct Cost	11.9	11.9	11.9	11.9	11.9	11.9	11.9	874.7
O/M Cost								
Sewers	9.8	9.8	9.8	9.8	9.8	9.8	9.8	202.2
Chachar Nala SPS	1.3	1.3	1.3	1.3	1.3	1.3	1.3	40.0
Gaughat MPS	3.7	3.7	3.7	3.7	3.7	3.7	3.7	91.8
Naini STP	29.9	29.9	29.9	29.9	29.9	29.9	29.9	777.4
Sub Total of O/M Cost	44.7	44.7	44.7	44.7	44.7	44.7	44.7	1,111.4
Sum of Direct Cost and O/M Cost	56.6	56.6	56.6	56.6	56.6	56.6	56.6	1,986.1
House Connection								
District A	13.5	13.5	13.6	13.6	13.6	13.6	13.6	311.6
Sub Total of House Connection Cost	13.5	13.5	13.6	13.6	13.6	13.6	13.6	311.6
Land Acquisition								
District A								
Sub Total of Land Acquisition	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub Total	70.1	70.1	70.2	70.2	70.2	70.2	70.2	2,297.7

Table 9.24.2 Implementation/Investment Schedule, District B (Page 1 of 2)

	Stage I											Stage II							
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Direct Construction Cost																			
Trunk Sewer				44.1	44.1							8.6	8.7						
Rising Main				69.1	69.1														
Branch Sewer (B-1)				3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Branch Sewer (B-2)							12.8	12.8	12.8	12.8	12.9	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Branch Sewer (FSA 2)												1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Lukerganj SPS				19.3	38.6														9.5
Ghaghar Nala MPS				53.3	106.5														16.6
Numaya Dahi STP				26.7	53.3														
Sub Total of Direct Cost				216.2	315.3	3.7	16.5	16.5	16.5	16.5	16.6	20.8	20.9	12.2	12.2	12.2	12.2	12.2	38.3
O/M Cost																			
Sewers				2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Lukerganj SPS						1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Ghaghar Nala MPS						4.0	4.0	4.0	4.0	4.0	4.0	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Numaya Dahi STP						5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Sub Total of O/M Cost				0.0	0.0	0.0	0.0	0.0	12.5	12.5	12.5	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1
Sum of Direct Cost and O/M Cost				216.2	315.3	3.7	16.5	16.5	29.0	29.0	29.1	35.9	36.0	27.3	27.3	27.3	27.3	27.3	53.4
House Connection																			
House Connection (B-1)				4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	5.2	5.2	5.3	5.3	5.3	5.3	5.3	5.3
House Connection (B-2)							4.0	4.0	4.0	4.0	4.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
House Connection (FSA 2)												1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7
Sub Total of House Connection				4.8	4.8	4.8	8.8	8.9	8.9	8.9	8.9	11.3	11.3	11.4	11.4	11.4	11.4	11.5	11.5
Land Acquisition																			
Treatment Plant						275.2													
Pumping Station						4.0													
Sub Total of Land Acquisition				0.0	0.0	279.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Cost				221.0	320.1	287.7	25.3	25.4	37.9	37.9	38.0	47.2	47.3	38.7	38.7	38.7	38.7	38.8	64.9

Table 9.24.2 Implementation/Investment Schedule, District B (Page 2 of 2)

	Stage II							Total
	2024	2025	2026	2027	2028	2029	2030	
Direct Construction Cost								
Trunk Sewer								105.5
Rising Main								138.2
Branch Sewer (B-1)	3.9	4.0	4.0	4.0	4.0	4.0	4.0	88.7
Branch Sewer (B-2)	6.4	6.4	6.4	6.4	6.4	6.4	6.5	160.2
Branch Sewer (FSA 2)	1.9	1.9	1.9	1.9	2.0	2.0	2.0	28.8
Lukerganj SPS								67.4
Ghaghar Nala MPS								176.4
Numaya Dahi STP								80.0
Sub Total of Direct Cost	12.2	12.3	12.3	12.3	12.4	12.4	12.5	845.2
O/M Cost								
Sewers	4.6	4.6	4.6	4.6	4.6	4.6	4.6	89.0
Lukerganj SPS	1.3	1.3	1.3	1.3	1.3	1.3	1.3	25.5
Ghaghar Nala MPS	4.2	4.2	4.2	4.2	4.2	4.2	4.2	87.0
Numaya Dahi STP	5.0	5.0	5.0	5.0	5.0	5.0	5.0	105.0
Sub Total of O/M Cost	15.1	15.1	15.1	15.1	15.1	15.1	15.1	264.0
Sum of Direct Cost and O/M Cost	27.3	27.4	27.4	27.4	27.5	27.5	27.6	1,109.2
House Connection								
House Connection (B-1)	5.3	5.3	5.3	5.3	5.3	5.3	5.3	118.1
House Connection (B-2)	4.6	4.6	4.6	4.6	4.6	4.6	4.6	88.2
House Connection (FSA 2)	1.7	1.7	1.7	1.7	1.7	1.7	1.7	24.9
Sub Total of House Connection	11.6	11.6	11.6	11.6	11.6	11.6	11.6	231.2
Land Acquisition								
Treatment Plant								275.2
Pumping Station								4.0
Sub Total of Land Acquisition	0.0	0.0	0.0	0.0	0.0	0.0	0.0	279.2
Sub Total	38.9	39.0	39.0	39.0	39.1	39.1	39.2	1,619.6

Table 9.24.3 Implementation/Investment Schedule, District C (Page 1 of 2)

	Stage I											Stage II								
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Direct Construction Cost																			
Trunk Sewer												49.6	49.6	49.7	49.7	49.7			
Branch Sewer												16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
Salori STP				(sanc)	(sanc)	(sanc)							27.6						
Sub Total of Direct Cost				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.2	93.8	66.3	66.3	66.3	16.6	16.6	16.6
O/M Cost																			
Sewers												5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Salori STP							13.5	13.5	13.5	13.5	13.5	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3
Sub Total of O/M Cost							13.5	13.5	13.5	13.5	13.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Sum of Direct Cost and O/M Cost				0.0	0.0	0.0	13.5	13.5	13.5	13.5	13.5	86.7	114.3	86.8	86.8	86.8	37.1	37.1	37.1
House Connection																			
District C												14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
Sub Total of House Connection				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
Land Acquisition																			
District C																			
Sub Total of Land Acquisition				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Cost				0.0	0.0	0.0	13.5	13.5	13.5	13.5	13.5	101.5	129.1	101.6	101.6	101.6	51.9	51.9	51.9

Table 9.24.3 Implementation/Investment Schedule, District C (Page 2 of 2)

	Stage II							Total
	2024	2025	2026	2027	2028	2029	2030	
Direct Construction Cost								
Trunk Sewer								248.3
Branch Sewer	16.6	16.6	16.6	16.6	16.6	16.6	16.7	249.1
Salori STP								27.6
Sub Total of Direct Cost	16.6	16.6	16.6	16.6	16.6	16.6	16.7	525.0
O/M Cost								
Sewers	5.2	5.2	5.2	5.2	5.2	5.2	5.2	78.0
Salori STP	15.3	15.3	15.3	15.3	15.3	15.3	15.3	297.0
Sub Total of O/M Cost	20.5	20.5	20.5	20.5	20.5	20.5	20.5	375.0
Sum of Direct Cost and O/M Cost	37.1	37.1	37.1	37.1	37.1	37.1	37.2	900.0
House Connection								
District C	14.8	14.8	14.8	14.9	14.9	14.9	14.9	222.4
Sub Total of House Connection	14.8	14.8	14.8	14.9	14.9	14.9	14.9	222.4
Land Acquisition								
District C								
Sub Total of Land Acquisition	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Cost	51.9	51.9	51.9	52.0	52.0	52.0	52.1	1,122.4

Table 9.24.4 Implementation/Investment Schedule, District D (Page1 of 2)

	Stage I											Stage II							
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Direct Construction Cost																			
Trunk Sewer (Pumping Area)				50.4	50.5	50.5	50.5	50.5											
Trunk Sewer (Gravity Sewer Area)												28.4	28.5	28.5	28.5	28.5			
Rising Main				26.8	26.9	26.9													
Branch Sewer																			
Pumping Area				6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
Gravity Sewer Area												21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
Daraganj SPS																			6.0
Allahpur SPS																			6.4
Morigate Nala SPS					18.3	36.5													8.0
Alopibagh SPS					3.3														16.0
Mumfodganj SPS					66.1	132.1													20.1
Rajapur STP				125.0	250.0	250.0						45.0							
Sub Total of Direct Cost	0.0	0.0	0.0	208.6	421.5	502.4	56.9	56.9	6.4	6.4	6.4	104.7	59.8	59.8	59.8	59.8	31.3	31.3	87.8
O/M Cost																			
Sewers							4.7	4.7	4.7	4.7	4.7	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
Daraganj SPS							0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Allahpur SPS							0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Morigate Nala SPS							2.3	2.3	2.3	2.3	2.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Alopibagh SPS							3.6	3.6	3.6	3.6	3.6	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Mumfodganj SPS							3.1	3.1	3.1	3.1	3.1	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Rajapur STP							14.3	14.3	14.3	14.3	14.3	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6
Sub Total of O/M Cost				0.0	0.0	0.0	29.2	29.2	29.2	29.2	29.2	38.9	38.9	38.9	38.9	38.9	38.9	38.9	38.9
Sum of Direct Cost and O/M Cost				208.6	421.5	502.4	86.1	86.1	35.6	35.6	35.6	143.6	98.7	98.7	98.7	98.7	70.2	70.2	126.7
House Connection																			
Pumping Area				6.5	6.6	6.6	6.6	6.6	6.6	6.6	6.6	9.6	9.7	9.7	9.7	9.7	9.7	9.7	9.7
Gravity Sewer Area												15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8
Sub Total of House Connection				6.5	6.6	6.6	6.6	6.6	6.6	6.6	6.6	25.4	25.5	25.5	25.5	25.5	25.5	25.5	25.5
Land Acquisition																			
Rajapur STP				136.0															
Sub Total of Land Acquisition				136.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Cost				351.1	428.1	509.0	92.7	92.7	42.2	42.2	42.2	169.0	124.2	124.2	124.2	124.2	95.7	95.7	152.2

Table 9.24.4 Implementation/Investment Schedule, District D (Page2 of 2)

	Stage II							Total
	2024	2025	2026	2027	2028	2029	2030	
Direct Construction Cost								
Trunk Sewer (Pumping Area)								252.4
Trunk Sewer (Gravity Sewer Area)								142.4
Rising Main								80.6
Branch Sewer								
Pumping Area	10.2	10.2	10.3	10.3	10.3	10.3	10.3	204.7
Gravity Sewer Area	21.1	21.1	21.1	21.2	21.2	21.2	21.2	316.9
Daraganj SPS								6.0
Allahpur SPS								6.4
Morigate Nala SPS								62.8
Alopibagh SPS								19.3
Mumfodganj SPS								218.3
Rajapur STP								670.0
Sub Total of Direct Cost	31.3	31.3	31.4	31.5	31.5	31.5	31.5	1,979.8
O/M Cost								
Sewers	10.8	10.8	10.8	10.8	10.8	10.8	10.8	185.5
Daraganj SPS	0.7	0.7	0.7	0.7	0.7	0.7	0.7	13.5
Allahpur SPS	0.6	0.6	0.6	0.6	0.6	0.6	0.6	12.0
Morigate Nala SPS	1.3	1.3	1.3	1.3	1.3	1.3	1.3	31.0
Alopibagh SPS	3.3	3.3	3.3	3.3	3.3	3.3	3.3	67.5
Mumfodganj SPS	3.6	3.6	3.6	3.6	3.6	3.6	3.6	69.5
Rajapur STP	18.6	18.6	18.6	18.6	18.6	18.6	18.6	350.5
Sub Total of O/M Cost	38.9	38.9	38.9	38.9	38.9	38.9	38.9	729.5
Sum of Direct Cost and O/M Cost	70.2	70.2	70.3	70.4	70.4	70.4	70.4	2,709.3
House Connection								
Pumping Area	9.7	9.7	9.7	9.7	9.7	9.7	9.7	198.1
Gravity Sewer Area	15.8	15.8	15.8	15.8	15.8	15.9	15.9	237.2
Sub Total of House Connection	25.5	25.5	25.5	25.5	25.5	25.6	25.6	435.3
Land Acquisition								
Rajapur STP								136.0
Sub Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	136.0
Total Cost	95.7	95.7	95.8	95.9	95.9	96.0	96.0	3,280.6

Table 9.24.5 Implementation/Investment Schedule, District E (Page1 of 2)

	Stage I											Stage II							
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Direct Construction Cost																			
Trunk Sewer												41.6	41.6	41.6	41.7	41.7			
Branch Sewer												23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8
Sulemsarai STP				15.0	30.0							15.0	30.0						
Ponghat Nala STP				5.3	10.7														
Sub Total of Direct Cost				20.3	40.7							80.4	95.4	65.4	65.5	65.5	23.8	23.8	23.8
O/M Cost																			
Sewers												5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
Kodara STP						6.0	6.0	6.0	6.0	6.0	6.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Ponghat STP						2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Sub Total of O/M Cost				0.0	0.0	8.6	8.6	8.6	8.6	8.6	8.6	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4
Sum of Direct Cost and O/M Cost				20.3	40.7	8.6	8.6	8.6	8.6	8.6	8.6	97.8	112.8	82.8	82.9	82.9	41.2	41.2	41.2
House Connection																			
District E												10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6
Sub Total of House Connection				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6
Land Acquisition																			
Sulemsarai STP				42.0															
Ponghat Nala STP				50.0															
Sub Total of Land Acquisition				92.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Cost				112.3	40.7	8.6	8.6	8.6	8.6	8.6	8.6	108.4	123.4	93.4	93.5	93.5	51.8	51.8	51.8

Table 9.24.5 Implementation/Investment Schedule, District E (Page2 of 2)

	Stage II							Total
	2024	2025	2026	2027	2028	2029	2030	
Direct Construction Cost								
Trunk Sewer								208.2
Branch Sewer	23.8	23.8	23.8	23.8	23.9	23.9	23.9	357.3
Sulemsarai STP								90.0
Ponghat Nala STP								16.0
Sub Total of Direct Cost	23.8	23.8	23.8	23.8	23.9	23.9	23.9	671.5
O/M Cost								
Sewers	5.8	5.8	5.8	5.8	5.8	5.8	5.8	87.0
Kodara STP	9.0	9.0	9.0	9.0	9.0	9.0	9.0	171.0
Ponghat STP	2.6	2.6	2.6	2.6	2.6	2.6	2.6	54.6
Sub Total of O/M Cost	17.4	17.4	17.4	17.4	17.4	17.4	17.4	312.6
Sum of Direct Cost and O/M Cost	41.2	41.2	41.2	41.2	41.3	41.3	41.3	984.1
House Connection								
District E	10.6	10.6	10.6	10.6	10.6	10.7	10.7	159.2
Sub Total of House Connection	10.6	10.6	10.6	10.6	10.6	10.7	10.7	159.2
Land Acquisition								
Sulemsarai STP								
Ponghat Nala STP								50.0
Sub Total of Land Acquisition	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
Total Cost	51.8	51.8	51.8	51.8	51.9	52.0	52.0	1,193.3

Table 9.24.6 Implementation/Investment Schedule, District F

	Stage II															Total
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Direct Construction Cost																
Trunk Sewer	11.5	11.5	11.5	11.5	11.5											57.5
Branch Sewer	4.7	4.7	4.7	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	71.6
Phaphamau STP	5.3	10.7														16.0
Sub Total of Direct Cost	21.5	26.9	16.2	16.2	16.3	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	145.1
O/M Cost																
Sewers	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	21.0
Phaphamau STP			2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	33.8
Sub Total of O/M Cost	1.4	1.4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	54.8
Sum of Direct Cost and O/M Cost	22.9	28.3	20.2	20.2	20.3	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	199.9
House Connection																
District F	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.4	2.4	34.7
Sub Total of House Connection	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.4	2.4	34.7
Land Acquisition																
Phaphamau STP	50.0															50.0
Sub Total of Land Acquisition	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
Total Cost	75.2	30.6	22.5	22.5	22.6	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.2	11.2	284.6

Table 9.24.7 Implementation/Investment Schedule, District G

	Stage II															Total
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Direct Construction Cost																
Trunk Sewer	26.7	26.8	26.8	26.8	26.8											133.9
Branch Sewer																
Zone G	15.5	15.5	15.5	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	233.7
FSA 1	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.5	198.3
Mawaiya STP	27.0	54.0	54.0													135.0
Sub Total of Direct Cost	82.4	109.5	109.5	55.6	55.6	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	29.1	700.9
O/M Cost																
Sewers	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	105.0
Mawaiya STP				11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	133.2
Sub Total of O/M Cost	7.0	7.0	7.0	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	238.2
Sum of Direct Cost and O/M Cost	89.4	116.5	116.5	73.7	73.7	46.9	46.9	46.9	46.9	46.9	46.9	46.9	46.9	46.9	47.2	939.1
House Connection																
Zone G	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.8	9.8	9.8	9.8	9.8	9.8	9.8	146.2
FSA 1	4.8	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	72.9
Sub Total of House Connection	14.5	14.5	14.5	14.5	14.5	14.5	14.6	14.6	14.7	14.7	14.7	14.7	14.7	14.7	14.7	219.1
Land Acquisition																
Mawaiya STP	63.2															63.2
Sub Total of Land Acquisition	63.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.2
Total Cost	167.1	131.0	131.0	88.2	88.2	61.4	61.5	61.5	61.6	61.6	61.6	61.6	61.6	61.6	61.9	1,221.4

Table 9.25 Stage I Project - Implementation Cost

(Million Rs.)

Project	Estimated Cost	+Physical Contingency	Cumulative Cost
1. District A Augment Naini STP and rehabilitation of existing facilities			
(a) Augmentation of Naini STP from 60 to 80 mld	54.0	64.8	
(b) Rehabilitation of Chachar Nala SPS	4.6	5.5	
(c) Rehabilitation of Trunk Sewers and Installing trunk sewer	332.3	398.8	
(d) Branch Sewer	76.3	91.6	
Sub Total	467.2	560.7	560.7
2. District B Divert excess wastewater from Distict A and intercept Ghaghar Nala			
(a) Reconstructin of Lukerganj SPS	57.9	69.5	
(b) Installation of Trunk Sewer	88.2	105.8	
(c) Installation of Rising Main	138.3	165.9	
(d) Construction of Numaya Dahi STP	80.0	96.0	
(e) Land Acquisition of Numaya Dahi STP	275.2	275.2	
(f) Construction of Ghaghar Nala SPS	159.8	191.8	
(g) Land Acquisition of Ghaghar Nala SPS	4.0	4.0	
(h) Branch Sewer	93.6	112.3	
Sub Total	896.9	1,020.5	1,581.2
3. District D Divert excess wastewater from Distict A and intercept Morigate Nala and Rajapur Nala			
(a) Construction of Rajapur STP	625.0	750.0	
(b) Land Acquisition of Rajapur STP	136.0	136.0	
(c) Reconstruction of Morigate SPS	54.8	65.8	
(d) Installation of Rising Main from Morigate Nala SPS	18.4	22.1	
(e) Installation of Rising Main from Alopibagh SPS	34.5	41.4	
(f) Increase capacity of sump	3.3	4.0	
(g) Reconstruction of Mumforganj SPS	198.2	237.8	
(h) Installation of Rising Main from Mumfordganj SPS	27.6	33.1	
(i) Rehabilitation of Trunk Sewers and Installing Trunk Sewer	252.4	302.8	
(j) Branch Sewer	51.2	61.4	
Sub Total	1,401.4	1,654.4	3,235.6
4. District E Intercept Kodara Nala and Ponghat Nala			
(a) Construction of Sulemsarai STP	45.0	54.0	
(b) Land Acquisition of Sulemsarai STP	42.0	42.0	
(c) Construction of Ponghat Nala STP	16.0	19.2	
(d) Land Acquisition of Ponghat Nala STP	50.0	50.0	
Sub Total	153.0	165.2	3,400.8
Total	2,918.6	3,400.8	3,400.8

CHAPTER 10

INITIAL ENVIRONMENTAL EXAMINATION (IEE) STUDY FOR ALLAHABAD

CHAPTER 10 INITIAL ENVIRONMENTAL EXAMINATION (IEE)STUDY FOR ALLAHABAD

10.1 OBJECTIVE OF THE IEE STUDY

IEE is a very important and useful planning tool for development projects/programs at early stage. Original formulation of any projects/programs may be modified, if significant negative impact is predicted by the IEE. According to the JICA Environmental Guidelines, IEE is defined as "an examination undertaken at the outset of the development project planning stage to determine the environmental impacts that may be created by the particular project based on existing information and data."

The IEE has the following two objectives:

(1) To evaluate whether EIA is necessary for the project and, if so, to define its contents.
(2) To examine from an environmental viewpoint, the measures for mitigating the impacts of the project, which requires environmental consideration but not a full-scale environmental impact assessment.

For the above objectives, the study on IEE has investigated (1) The existing social and natural environmental conditions of the Study area, (2) Constraints and problems for the master plan projects/programs on the water quality management for Ganga River.

10.2 METHODOLOGY OF THE IEE STUDY

10.2.1 Procedure

There are three steps for the IEE as follows.

(a) Identification of master plan projects/programs for the IEE,
(b) Survey evaluation of environmental impact at the construction or rehabilitation and the operation stage by using an environmental impact checklist, and
(c) Output of evaluation.

10.2.2 Evaluation of Environmental Elements

An environmental impact matrix is used as a checklist of environmental effects. Environmental elements of impact matrix are based on JICA Guideline including JBIC Guideline. The major components are social issues, demographic issues, economic activity, institutional and custom related issues, health and sanitary issues, and cultural asset issues as social environment, and biological and ecological issues, soil resources, land resources, hydrology, water quality and temperature, pollution and landscape as natural environment.

10.3 SURVEY AREA

The survey area is four (4) cities of Lucknow, Kanpur, Allahabad and Varanasi. This part of the Report focuses on Allahabad.

10.4 PROJECTS/PROGRAMS FOR THE IEE STUDY

(a) District A

(1) Rehabilitation of Old Trunk Sewers
(2) Rehabilitation of Gaughat MPS
(3) Augmentation of Treatment Plant, Naini STP

(4) Installation of Sewers, New Trunk Sewers of Lateral and Branch in District A

(b) District B

(5) Construction of Treatment Plant, Numaya Dahi STP
(6) Construction of Pumping Stations, Ghaghar Nala MPS
(7) Installation of Sewers, New Trunk Sewers of Lateral and Branch in District B

(c) District C

(8) Augmentation of Treatment Plant, Salori STP (Sanctioned)
(9) Installation of Sewers, New Trunk Sewers of Lateral and Branch in District C

(d) District D

(10) Construction of Treatment Plant, Rajapur STP
(11) Installation of Sewers, New Trunk Sewers of Lateral and Branch in District D
(12) Upgrading of Pumping Stations

(e) District E

(13) Construction of Treatment Plant, Kodara STP and Ponghat STP
(14) Installation of Sewers, New Trunk Sewers of Lateral and Branch in District E

(f) District F

(15) Construction of Treatment Plant, Phaphamau STP
(16) Installation of Sewers, New Trunk Sewers of Lateral and Branch in District F

(g) District G

(17) Construction of Treatment Plant, Mawaiya STP
(18) Installation of Sewers, New Trunk Sewers of Lateral and Branch in District G

10.5 EXISTING OF ENVIRONMENTAL CONDITION

Allahabad city is a major urban agglomeration located in the southern region of the State of U.P. It is located between $25^0$20’ N to $25^0$33’ N latitude and $81^0$42’ E to $81^0$55’ E longitude and situated at the confluence of two major rivers the Ganga and Yamuna.

The topography is generally flat with minor undulations with ground levels ranging between 80 m lowest and 96 m highest above MSL.

Climate of Allahabad is of near extreme character with high temperatures in summer and very cold conditions during winter. Recorded maximum and minimum temperatures during summer and winter are 47.8 ° C and 1.1 ° C respectively.

Allahabad receives on an average about 930 mm of rainfall annually, nearly 80 % of which occurs during the three rainy months of July, August, and September. Other periods of the year generally remains dry.

The major existing environmental conditions are as following.

(1) Drainage

The existing sewerage and drainage system covers only 40 % of Allahabad city. The system is very old and dilapidated, and 57 nalas/drains are identified to be carrying wastewater and polluting the Ganga and Yamuna Rivers. Out of the 57 nalas/drains, 44 nalas/drains discharge wastewater into the Ganga River and 13 drains discharge into the Yamuna river. The other major drainage channels are

Sasur Khaderi river, Kasari Masari nala, Basara nala and Nagbasuki nala, etc. which discharge into either of the two rivers.

(2) Major Sewerage System

There is one Sewage Treatment Plant (STP) named as Naini STP which gets waste water from Gaughat main pumping station (MPS). At Naini STP, the efficiency of treatment has been 75.54, 88.74 and 88.62 %, respectively in terms of BOD, SS and COD (averages in May 2002).

(3) Wastewater Irrigation

In Allahabad, there are two sewage farm areas which get waste water discharge from Gaughat main pumping station and Naini STP across Yamuna river at south of Allahabad city. Two farms that occupy about 2,000 hectare. The farmers cultivate flowers, vegetables and grains.

(4) Industrial Scenario

Southern part of Naini area is earmarked for industrial uses such. In the industrial estate, a number of large, and medium scale industries have been set up in this area. Additionally, few major industrial establishments also operate from Sherwani Nagar area and some other parts of the city.

(5) Open Space

Prime open spaces with recreational facilities are in Khusroobagh, the Stadium Complex, Minto Park, Motilal Nehru Park, and Children Park.

10.6 EVALUATION AND CONCLUSION OF THE IEE STUDY

The Ministry of Environment and Forests (MoEF) enforced the notification in January 1994 and amended it in May 1997, April 1997, January 2000, December 2000, August 2001 and November 2001 for conducting Environmental Impact Assessment (EIA) studies which are obligatory for the establishment of certain categories of industries specified in Schedule I. The Schedule I industries include 30 categories. The appraisal committees comprising experts, Governmental official and non-government organisations (NGOs) were set up by the MoEF to scrutinise various EIAs prepared for the establishment of such industries and projects. The appraisal committees would accord an environmental clearance to the project in consultation with MoEF after scrutinising the EIA report for the proposed project. Sewerage project is not included in these industries and does not require EIA study according to the Notification.

An Initial Environmental Examination (IEE) for the proposed project components in the Master Plan for the four cities was carried out by JICA Study Team based on a JICA guideline, to briefly identify the impacts of the facilities proposed in the Sewerage Master Plans on natural and social environment. The important environmental issues are identified and the impacts are ranked as (A) strong impact, (B) medium impact, (C) not fully known, and (blank) no major impact during the construction and operation stage.

The results of the IEE to Master Plan Projects that have been planned for Allahabad city are shown in Table 10.1. The major impacts identified for the proposed facilities are related to construction and operation of sewage treatment plants as given in table below.

Impact items	**Phase**	**Spatial range**	**Time range**	**Range/ affected people**
1. Land acquisition for construction of STP	Construction	Agricultural field	Long term	Farmers
2. Income loss of agriculture due to construction of STP in agricultural field	Construction	(Social issue)	Long term	Farmers
3. Landscape and land use change	Construction	Agricultural field	Long term	Nearby villagers
4. Sludge disposal from STP	Operation	Disposal sites	Long term	Disposal sites
5. Contamination of surface water and groundwater by discharging treated effluent and seepage from STP	Operation	River, irrigation canal and groundwater	Long term	Nearby villagers
6. Contamination of soil through application of treated water and dried sludge	Operation	Agricultural field	Long term	Farmers

The proposed projects are, however, in general, environmental mitigation projects by providing sewerage system to properly dispose of municipal sewage. Therefore, the projects themselves have preferable environmental impacts on the water environment and the public health of the residents.

Table 10.1 Possible Environmental Impact Matrix for IEE

Environmental Elements / Development Scheme		Social Environment									Natural Environment								Pollution					
		Resettlement	Economic Activity	Traffic/Public Facilities	Split of Communities	Cultural Properties	Water Right/Right of Common	Public Health Condition	Solid Waste	Hazard	Topography and Geology	Soil Erosion	Groundwater	Hydrological Situation	Coastal Zone	Flora and Fauna	Local Meteorology	Landscape	Air Pollution	Water Pollution	Soil Contamination	Noise and Vibration	Ground Subsidence	Odour
Sewage Treatment Plant	**C**	B/C	B/C	C					C									B/C				C		
	O							C	C				B/C	C						B/C	B/C	C		C
Pumping Station	**C**	C		C																		C		
	O							C	C													C		
Installation of Main Trunk Sewer	**C**		C	C																		C		
	O																							
Rehabilitation of Existing Trunk sewer	**C**		C	C				C												C		C		C
	O																							

Remarks:

C: Indicates construction (rehabilitation) stage. **O**: Indicates operation stage.

A: Indicates that the development scheme is foreseen to have strong impact on the environmental element.

B: Indicates that the development scheme is foreseen to have some impact on the environmental element.

C: Indicates that the development scheme is foreseen to have minor impact on the environmental element

Balnk: indicates no impact