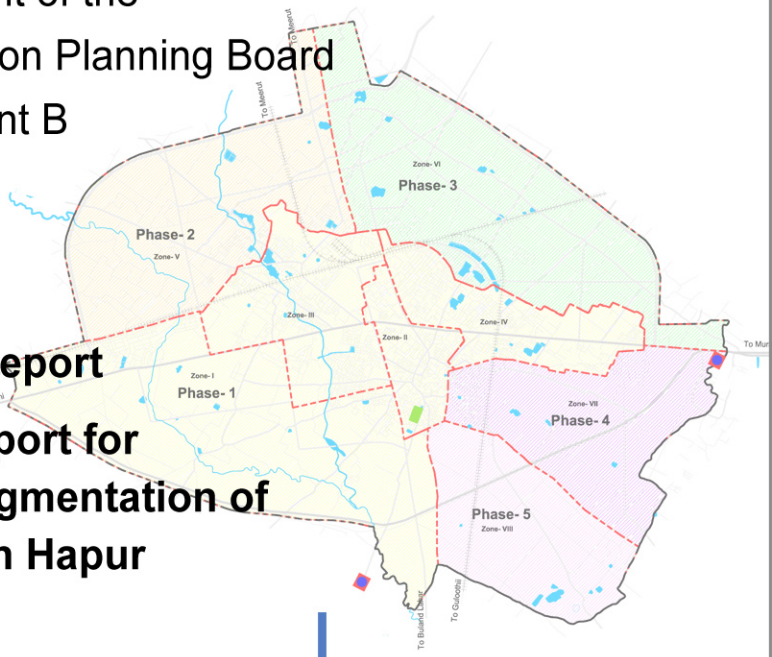
FINAL REPORT

Asian Development Bank

National Capital Region Planning Board

Capacity Development of the
National Capital Region Planning Board
Package 2 Component B
TA No. 7055-IND



Volume II-A: Main Report

Detailed Project Report for Rehabilitation & Augmentation of Sewerage System in Hapur

WilburSmith ASSOCIATES

July 2010

NCR Planning Board
Asian Development Bank

Capacity Development of the National Capital Region Planning Board (NCRPB) – Component B

(TA No. 7055-IND)

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Volume II-A: Detailed Project Report for Rehabilitation & Augmentation of Sewerage System in Hapur

Main Report

July 2010

Abbreviations

ADB	:	Asian Development Bank
BOD	:	Biochemical Oxygen Demand
CI	:	Cast Iron
CMA	:	Counter Magnet Areas
DFR	:	Draft Final Report
DI	:	Ductile Iron
DPR	:	Detailed Project Report
EIA	:	Environmental Impact Assessment
GoUP	:	Government of Uttar Pradesh
HDPE	:	High Density Polyethylene
HH	:	Household
HUDA	:	Hapur Urban Development Authority
JNNURM	:	Jawaharlal Nehru Urban Renewal Mission
KV	:	Kilo Volts
KW	:	Kilo Watts
LPCD	:	Liters Per Capita per Day
MGD	:	Million Gallons per Day
MLD	:	Million Liters per Day
MoUD	:	Ministry of Urban Development
MPN	:	Most Probable Number
NCR	:	National Capital Region
NCRPB	:	National Capital Region Planning Board
NCT	:	National Capital Territory
NH	:	National Highway
NTU	:	Neflo Turbidity Units
O & M	:	Operation and Maintenance
PPP	:	Public Private Partnership
PSC	:	Pre-stressed Concrete
RCC	:	Reinforced Cement Concrete
Rs.	:	Indian Rupees
SH	:	State Highway
SOI	:	Survey of India
SOR	:	Schedule of Rates
SPS	:	Sewage Pumping Station
STP	:	Sewerage Treatment Plant
UIT	:	Urban Improvement Trust
ULB	:	Urban Local Body
UP	:	Uttar Pradesh
uPVC	:	Unplasticized Polyvinyl Chloride
WB	:	World Bank
WSP	:	Waste Stabilization Pond

Glossary of Terms

Aerated Lagoons: Like Waste Stabilization Pond (WSP), but with mechanical aeration. Oxygen requirement mostly from aeration and hence more complicated and higher O&M costs require less land than WSP.

*Activated Sludge Proces*s: 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 maintains aerobic conditions.

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

Assimilative Capacity: The ability of a water body to receive wastewater and toxic materials without deleterious effects on aquatic life or 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 20ºC.

Biological Process: The process by which the metabolic activities of bacteria and other microorganisms 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.

Coli form Bacteria: Rod shaped bacteria from intestinal tract 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.

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.

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

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.

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.

Methane: A colorless, odorless, combustible gas that is the principal by-product of anaerobic decomposition or organic matter in wastewater. Chemical formula is CH4.

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 prepares wastewater influent for further treatment.

Pump Station: (see Lift Station)

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 conditions 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 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 are 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 poor quality effluent than processes such as ASP (NOTE: other anaerobic processes exist, but UASB is the most common at present).

Collection System Terminology

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

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

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

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

Pumping Main: Pumping mains are used to convey wastewater from pumping stations to treatment plants at higher elevations. They are also referred as rising mains or force mains.

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Compendium Volumes

Besides this Volume II-A, the DPR for Rehabilitation & Augmentation of Sewerage System in Hapur, has following Volumes appended separately.

Volume II-B: Detailed Designs (Appendices D-1 to D-14)

Volume II-C: Detailed Estimates (Appendices E-1 to E-47)

Volume II-D: Detailed Drawings

Volume II-E: Financial & Economic Analysis

Volume II-F: Initial Environmental Examination

Volume II-G: Resettlement Plan

1. INTRODUCTION

A. Background

1. The National Capital Region Planning Board, constituted in 1985 under the provisions of NCRPB Act, 1985, is a statutory body functioning under the Ministry of Urban Development, Government of India. NCRPB has a mandate to systematically develop the National Capital Region (NCR) of India. It is one of the functions of the Board to arrange and oversee the financing of selected development projects in the NCR through Central and State Plan funds and other sources of revenue.

2. On Government of India's request, Asian Development Bank (ADB) has formulated the technical assistance (TA) to enhance the capacities of National Capital Region Planning Board and its associated implementing agencies. The TA has been designed in three components: Component A relates to improving the business processes in NCRPB; Component B relates to improving the capacity of the implementing agencies in project identification, feasibility studies and preparing detailed engineering design; and Component C relates to urban planning and other activities.

3. ADB has appointed M/s Wilbur Smith Associates to perform consultancy services envisaged under Component B. In the context of this contract, the first deliverable – Inception Report, was submitted in October 2008. The second deliverable –Interim Report comprising Master Plan for sewerage in Hapur, Master Plan for Water Supply for Panipat, Master Plan for Drainage for Hapur, Master Plan for Solid Waste management for Ghaziabad, Traffic and Transport analysis for Ghaziabad, Socio-Economic base line survey result in 3 sample project towns and proceedings of workshop 1 was submitted in January 2009. The four Master Plans as stated above are also made available on NCRPB web site for use of the implementing agencies.

4. The third deliverable Draft Final Report (DFR) comprising Detailed Project Report (DPR) for water supply in Panipat, DPR for sewerage in Hapur, DPR for drainage in Hapur, DPR for drainage in Sonipat, DPR for solid waste management in Ghaziabad, DPR for four selected transport components (Flyover, Road widening, Multi-level Parking and Bus Terminal) in Ghaziabad, and a Report on Capacity Building Activities were submitted.

5. Now, this is the Final Report (FR) and is the fourth and final deliverable. The comments/feedback on Draft Final Report received from ADB, NCRPB and respective implementing agencies, if any, were duly incorporated and final DPRs for components of Water Supply, Sewerage, Drainage, Solid Waste Management, and Transport are submitted as part of this Final Report. This is the Detailed Project Report for Sewerage System Improvement in Hapur.

B. Overview of this ADB TA

6. *Objectives*. The objective of this TA is to strengthen the capacity at NCRPB, state-level NCR cells, and other implementing agencies in the area of planning for urban infrastructure and to impart necessary skills to conceive, design, develop, appraise and implement good quality infrastructure projects for planned development of NCR. The increased institutional capacity of the NCRPB and the implementing agencies will lead to effective and time scaling-up of urban infrastructure to (i) improve quality of basic urban services in the NCR; (ii) develop counter magnet towns; (iii) reduce in migration into Delhi and orderly development of NCR; and (iv) accelerate economic growth in the NCR.

7. The TA – Capacity Development of the NCRPB, Component B focuses on strengthening the capacities of NCRPB and implementing agencies relating to project feasibility studies and preparation, and detailed engineering design in the implementing agencies. Specifically this component B of the TA will support the project preparation efforts of the implementing agencies by preparing demonstration feasibility studies that include all due diligence documentation required for processing of the project in accordance with best practices, including ADB's policies and guidelines.

8. *Scope of Work*. According to the terms of reference of the TA assignment, the following activities are envisaged in component B of the TA:

   (i) Conduct technical, institutional, economic and financial feasibility analysis of identified subprojects in the six sample implementing agencies;
   (ii) Conduct safeguards due diligence on the subprojects, including environmental assessment report and resettlement plan for all subprojects covered in the sample implementing agencies;
   (iii) Prepare environmental assessment framework and resettlement framework; and
   (iv) Develop a capacity building and policy reform program for the implementing agencies, including governance strengthening, institutional development and financial management.

9. Besides, this component of the TA will also:

   (i) help in assessing the current practices and procedures of project identification and preparation of detailed project reports including technical, financial, economic and social safeguard due diligence;
   (ii) support preparation of standard procedure manuals for project identification and preparation of detailed project reports including technical, financial, economic and social safeguard due diligence;
   (iii) train the implementing agencies in the preparation of detailed project reports by using the sample subprojects, reports on deficiency of current practices and standard protocol manuals; and
   (iv) help in developing a user-friendly web-page where different manuals and guidelines for preparation of DPRs will be made available for the implementing agencies.

C. About this Final Report

10. At Interim Report stage of the TA, the Master Plans for Water Supply in Panipat, Sewerage system in Hapur, Drainage for Hapur and Municipal Solid Waste Management for Ghaziabad were prepared. The Master Plans provided 100 percent coverage of population and the area likely to be in planning horizon year 2031/2041. All works required up to planning horizon year were conceptualized, broadly designed and block cost was estimated. The Master Plans also provided phasing of investment such that under phase 1 works required to cover present spread of city were proposed.

11. Now, Detailed Project Reports (DPRs) have been prepared for Phase 1 works as suggested in the Master Plans. For preparation of DPRs, engineering surveys and investigations have been conducted and various possible and feasible alternatives have been evaluated. Finally for the selected options the DPRs have been prepared with detailed designs, item wise detailed cost estimate, work specifications, implementation process and proposed implementation arrangements. Further, according to ADB procedures these DPRs in addition to technical analysis included institutional, financial and economic feasibility analysis and environmental and social safeguards due diligence – environmental assessment and resettlement plans.

12. The DPR's submitted as part of Draft Final Report was reviewed by the implementing agencies, NCRPB and the ADB. Now this is the Final Report incorporating the comments of on DFR.

13. *Other Activities*. As part of the capacity development activities under this TA component B, two workshops were conducted during this DFR State. Workshop II on Master Plan Preparation Process for Urban Infrastructure was conducted on 9th April 2009 and workshop III on Municipal Solid Waste Management was conducted on 22nd May 2009 for capacity development of NCRPB and Implementing Agencies. Proceedings of these workshops are appended to this DFR. A national tour also organized as part of this TA during the DFR preparation time to best practice urban infrastructure facilities in various places in India. This week-long tour was organized in 17-22 Aug 2009, and the participants include elected representatives and officials from NCR implementing agencies.

14. *Organization of the FR*. The Final Report of the TA Component B is organized in following Six Volumes:

Volume I: Detailed Project Report for Rehabilitation and Augmentation of Water Supply System in Panipat

Volume II: Detailed Project Report for Rehabilitation and Augmentation of Sewerage System in Hapur

Volume III: Detailed Project Report for Rehabilitation of Major Drains in Hapur

Volume IV: Detailed Project Report for Improvement of Solid Waste Management System in Ghaziabad

Volume V: Detailed Project Reports for Four Transport Components in Ghaziabad

Volume VI: Proceedings of 2nd and 3rd Workshops

D. Structure of this Volume II Report

15. This is Volume II of the Final Report and is the Detailed Project Report for Sewerage System in Hapur. This DPR is presented **seven** sub-volumes (**Volumes IIA to IIG**) including this Main Report:

Volume II-A: Hapur Sewerage DPR Main Report:

- **Section 1** Introduction
- **Section 2** defines the scope and objectives of the DPR;
- **Section 3** establishes the Project Rationale;
- **Section 4** presents review of sanitation sector in India and presents a brief of the Sewerage Master Plan of Hapur;
- **Section 5** provides detail of project town Hapur;
- **Section 6** describes the existing Sewerage System in Hapur and its current status;
- **Section 7** presents study approach;
- **Section 8** establishes planning and design criteria for preparation of DPR for sewerage system in Hapur Town;
- **Section 9** presents the Detailed Design of the proposed sewerage system;
- **Section 10** provides Project cost estimates including operation and maintenance cost estimates;
- **Section 11** defines contract packages, reviews the institutional aspects of project implementation and operation and maintenance
- **Section 12**: Institutional analysis

Volume II-B: Detailed Designs

Volume II-C: Detailed Estimates

Volume II-D: Detailed Drawings

Volume II-E: Financial & Economic Analysis

Volume II-F: Initial Environmental Examination

Volume II-G: Resettlement Plan

2. PROJECT RATIONALE, SCOPE & OBJECTIVES

A. Project Rationale & Scope

16. *Back Ground*: Sewerage is the core element of physical infrastructure that determines status of any settlement and as such requires minute planning, development and management. Development of appropriate sewage carriage system with effluent treatment is the key element, which acts as a prerequisite for facilitating balance and harmonised development. Augmentation of existing inadequate systems/treatment facilities as well as adoption of new technologies of waste treatment for small and marginal settlements and rural areas presents a gigantic task demanding special efforts.

17. HPDA is developing 9 sectors comprising housing colonies, transport nagar, leather city and city centre in the area generally outside municipal boundary but within the Master Plan area. HPDA is laying internal sewerage system and disposing waste near the proposed sector. HPDA intends to have a connecting trunk sewer to carry sewage of all sectors and pump and treat waste water and then dispose it to fulfil pollution control act requirement of acceptable disposal of effluent. The HPDA is conscious to have comprehensive planning so that any waste generated in future from the area upstream of the proposed trunk sewer is also taken into consideration while designing the trunk sewer. HPDA approached NCRPB to prepare comprehensive scheme for Hapur.

18. The existing sewerage system in Hapur covers only 1/3rd of municipal area, it is almost defunct and treatment plant is not available. The scope of this study is broadly as follows:

(i) Comprehensive planning of sewerage system (Master Plan for Sewerage) in Hapur city for anticipated spread of the city in next 30 years (5,522 hectares) and develop the planned system in phases over the period of next 20 years so that the sewerage system is provided in the habituated area. At present the habituated area is generally in municipal boundary (1402 hectares) and as such the DPR is prepared for immediate investment required to cover municipal area

(ii) Rehabilitate, upgrade and renew existing sewerage system,

(iii) Provide sewage treatment plant and sewage pumping station

(iv) Design sewerage system to cover complete municipal area

(v) Provide trunk sewer for sectors being developed by HPDA, (internal sewerage system for HPDA sectors has not been included as it will be done by HPDA)

(vi) Provide low cost sanitation /site sanitation where required

(vii) Develop system for use of treated effluent

(viii) Cover all urban poor settlments

(ix) Connect house waste to sewerage system

(x) Improved Operation and Maintenance of sewerage system

(xi) Develop financially and environmentally sustainable sewerage system

B. Objectives

19. The objective of a public water collection and disposal system is to ensure that sewage or excreta and sullage discharged from communities is properly collected, transported, treated to the required degree and finally disposed off without causing any health or environmental problems. If the waste matter created and given out by human beings and animals and also by industries, etc., is allowed to accumulate it will get decomposed and will contaminate air, water and food resulting in outbreak of epidemic. The provision of sanitation facilities aims at the creation of such conditions of living which will prevent serious outbreak of epidemic and hence it is a measure for the preservation of health of community in general and of individual in particular.

20. At present the sewage is passing through drains. The drains are unpaved and as such causes ground water pollution. The waste water collected through sewers is pumped in open surface area. This also affects ground water quality adversely. Some of the drain water finds way to Kali Nadi and then to Ganga river and pollutes the River. With a proper sewage treatment plant the objective is no pollution load to Ganga River from the City.

C. Project Rationale

21. Project in conformity to National Policy: According to the information given in the India Water Supply & Sanitation published by World Bank in 2006, if access to sewers and septic tanks was about 43 percent in 1990, the MDG target should be about 72 percent at the end of the 12th Plan. The official figure is that about 62 percent are having access to basic sanitation in 2001. The discussion of future estimates presented in this report, is based on the following targets for the end of the 12th Plan (2017): (i) sanitation coverage ratio: about 82 percent broken down as follows: about 52 percent connected to sewers, 30 percent to septic tanks, and an additional 16 percent to latrines. However, Government of India envisages providing access to water supply facilities and sewerage and on-site sanitation facilities to 100 percent of the urban population by the end of the 11th Five Year Plan. Thus the proposed sewerage project for Hapur is essentially required and as per policy of GOI.

22. Project in conformity to NCR Regional Plan 2021: The Regional Plan 2021 has presented plan of actions, strategies and scheduled period by which proposed actions are to be taken as given below, as applicable for Hapur:

    (i) Master Plan for sewerage and its treatment should be prepared by 2006 and its implementation and monitoring should be monitored by the state government

    (ii) Hapur should have cent percent sewerage system and should treat their sewage up to the desired standards by 2012 and the existing sewerage system should be rehabilitated.

    (iii) The Master Plan/Development Plan should incorporate land allocations at appropriate locations for sewage treatment plants and sewage pumping stations by 2007

(iv) The overall management of surface drains and sewerage system with treatment facilities should be with single agency and policy of dual agencies should be discarded

(v) Recycling of waste water for non drinking water use should be promoted to the extent of at least 50% of waste water generated by 2007. If required, enabling provisions in the respective acts of the local bodies may be made by the state governments.

(vi) Mass awareness should be created for waste minimization by 2007

(vii) Commercial approach should be adopted by the local bodies for revenue generation. Tariff should be so fixed that it meets at least the Operation and Maintenance cost of the sewerage system, if not the capital cost of the system. Introduction of sewage tax and improved recovery of taxes may help in reducing the revenue-expenditure gap. The structure of the sewage tax should be demand based and increased telescopically depending upon the monthly consumption of water and should be reviewed periodically as a built-in mechanism to make the service self sustaining and a deterrent to wastage. The states should improve water tariff by 2007. Public-private partnership needs to be introduced for operation and maintenance of the sewerage schemes and sewage treatment plants.

(viii) Institutional capacity building measures should be adopted.

(ix) External Development Charges (EDC) should be proportionately spent for the development of physical infrastructure in the existing township and new area under development. This was to be done by year 2007.

(x) Provision for Special Component Plant for NCR in the five-year plan and Sub-component plan by the State governments should be made. Centrally sponsored Schemes for Infrastructure Development in NCR should be formulated and implemented.

23. Hapur City has not achieved the targets set in Regional Plan and as such it is important to take up sewerage system for Hapur.

(i) Improvement in quality of life: The quality of life will improve with elimination of bad smell in open drains and ease of disposal of waste water from the household

(ii) Improvement in Health: The insanitary and unhygienic conditions prevailing at the moment is a major source of illness among the residents. Sewerage system will result into sanitary and hygienic conditions. This will significantly reduce illness cases and effect improvement in health of residents.

(iii) Economic and Financial Considerations: The sewerage system will result in substantial economic gains. The initial investment in terms of sewerage system will be less than the cost of separate household sanitation system for each house particularly in congested and densely populated areas. Even the O & M cost for combined system may be less than the individual septic tank system. The economic gains of improvement in health, less illnesses and more work days due to less number of illnesses are significant.

(iv) Improvement in environment: The sewerage system will have positive impact on the environment as it will arrest pollution of air and ground water. The water bodies and drains will become cleaner. The quality of water in Kali River which at present is of black color will improve. Ganga River will receive less pollutant due to disposal of

treated effluent in the River.

24. The project preparation will be in two phases. First, Master Plan will be prepared. Main features of Master plan shall be,

(i) This will be a long term planning for 20 years;
(ii) Population projection will be done for next 30 years;
(iii) Likely spread of city in next 20 years will be found out;
(iv) Project Population density in different wards of municipal council and for the area outside municipal council to which town will spread for different years for next 30 years and work out population of small parts of city area;
(v) Collect details of existing sewerage system. Assess its capacity, performance, inadequacies and determine what part of it to be rehabilitated and what part to be replaced;
(vi) Collect existing topographical maps of city with contours;
(vii) Develop design criteria for sewerage system
(viii) Decide on treatment option, treatment site location and area required;
(ix) Need and location of sewage pumping stations;
(x) Determine zone boundary, zone population;
(xi) Decide alignment and size of outfall sewer and trunk sewer;
(xii) Prepare broad estimate of investment and phasing of investment;
(xiii) Consider social, R & R issues, financial, economical and environmental safe guards;
(xiv) Review institutional aspects-existing and for project implementation and operation and maintenance;
(xv) Capacity building of NCRPB and Implementing agencies in preparation of Master Plan for Sewerage;
(xvi) Project implementation strategy;
(xvii) Determine topographical survey requirements and issues to be further detailed in next phase of project preparation

25. Second phase of project preparation will be to prepare detailed project report. This will mainly comprise of:

i) Topographical surveys for the master plan area and engineering investigations such as soil characteristics, underground strata, permeability (for WSP STP) and bearing capacity, sewage characteristics etc.
ii) The scope of DPR will be limited to cover existing habitation and spread of city and trunck sewer for HPDA proposed sectors which is required to be implemented immediately. The remaining area proposed under urbanisation in the Master Plan shall be provided sewerage system in phased manner as per future development;
iii) It will find sewage generation from each street and individual units of big sewage generators;
iv) Undertake detailed design of network-laterals, trunk mains, interceptor, branch sewer and outfall sewer, pipes, beddings, appurtenances, sewage treatment plant,

sewage pumping stations etc and present pipe dia to be provided in each street, level, slope and alignment of all sewer lines;

v) Estimate all proposed works on item rate basis using schedule of Rates prevalent;

vi) Prepare detailed drawings of various elements of proposed sewerage system;

vii) Consider social, R & R issues, financial, economical and environmental safe guards;

viii) Review institutional aspects-existing and for project implementation and operation and maintenance;

3. SANITATION SECTOR REVIEW

A. Urban Sanitation Overview

1. Millennium Development Goals

26. The Millennium Development Goals (MDGs) (Goal No.7) enjoin upon the signatory nations requiring them "to halving the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015'' and 100 percent access by 2025. This implies extending coverage to households which are presently without improved sanitation, and providing proper sanitation facilities in public places to make cities open-defecation free. Since the early 1990s, India has made good progress in developing water supply and sanitation (WSS) infrastructure in urban areas. According to the information given in the India Water Supply & Sanitation published by World Bank in 2006, if access to sewers and septic tanks was about 43 percent in 1990, the MDG target should be about 72 percent at the end of the 12th Plan; with an official figure of about 62 percent in 2001, India should be able to exceed the MDG target. The discussion of future estimates presented in this report, is based on the following targets for the end of the 12th Plan (2017): (i) sanitation coverage ratio: about 82 percent broken down as follows: about 52 percent connected to sewers, 30 percent to septic tanks, and an additional 16 percent to latrines. However, Government of India envisages providing access to water supply facilities and sewerage and on-site sanitation facilities to 100 percent of the urban population by the end of the 11th Five Year Plan.

2. Sanitation Crisis in South Asia

27. Every one of two South Asians is still forced the indignity of defecating in the open, or using other forms of unimproved sanitation. There is a high disparity in access and use of sanitation facilities across socio-economic groups. Considerable number of women, girl-children, urban and rural poor and other vulnerable groups especially suffer the indignity, inconvenience, loss of time and energy due to lack of proper sanitation. Poor sanitation and hygiene kills a large number of South Asian children every day, and frequent diseases also cause widespread mal-nutrition amongst children, stunting their physical and mental growth. Poor sanitation causes huge economic losses to households and nations, apart from imposing alarming health and environmental costs for communities.

28. The Third South Asian Conference on Sanitation (SACOSAN) "sanitation for dignity and health" held on 16-21 Nov 2008 at New Delhi committed to achieving national goals and the Millennium Development Goals on Sanitation in a time-bound manner and prioritize sanitation as a development intervention for health, dignity and security of all members of communities especially infants, girl-children, women, the elderly and vulnerable and that achieving sanitation for all will be an inclusive process, involving all stakeholders at all stages, especially local governments, community and grassroots groups. SACOSAN has also agreed on a roadmap for achieving sanitation goals.

3. Urban Sanitation in India

29. Third of India's urban population does not have access to adequate sanitation; the situation is even more grim with respect to the urban poor. To address this situation and building on earlier initiatives, the Government of India has formally approved the National Urban Sanitation Policy in 2008 which envisions the creation of totally sanitized cities and towns. The policy articulates awareness generation and behavior change, open defecation free cities in which all urban dwellers have access to safe sanitation, integrated city wide sanitation planning and sanitary and safe disposal of urban wastes. In addition, the policy promotes community and local government participation in the planning, implementation and management of urban sanitation services. In urban sanitation too, the importance of sustainability is highlighted, specifically addressing the issue of 'willingness to charge' for services and the impact on environmental health.

30. According to the Census of 2001, 30.6 million urban households which form 35.49 percent of the urban households suffer inadequate access to sanitation facilities and more than 37 percent of the total human excreta generated in urban India is unsafely disposed. Out of these 30.6 million households, 12.04 million (7.87 percent) urban households do not have access to latrines and defecate in the open. 5.48 million (8.13 percent) urban households use community latrines and 13.4 million households (19.49 percent) use shared latrines. 12.47 million (18.5 percent) households do not have access to a drainage network. 26.8 million (39.8 percent) households are connected to open drains.

31. The status in respect of the urban poor is even worse. The percentage of notified and non-notified slums without latrines is 17 percent and 51 percent respectively. In respect of septic latrines the availability is 66 percent and 35 percent. In respect of underground sewerage, the availability is 30 percent and 15 percent respectively. 37 percent of the wastewater generated is let out into the environment untreated. Three-fourths of surface water resources are polluted and 60 percent of the pollution is due to sewage alone. Poor sanitation severely impacts public health, causes hardships and imposes huge medical expenditure, especially for the poor. The loss due to diseases caused by poor sanitation for children under 14 years alone in urban areas amounts to Rs. 5 billion at 2001 prices.

32. Information collected by CPHEEO, Ministry of Urban Development indicates that as on 31.03.07, about 63 percent of the urban population have got access to sewerage, low cost sanitation and septic tank facilities at present i.e. about 30 percent population have got access to sewerage and 33 percent have got access to low cost sanitation and septic tank facilities. The coverage figures mentioned above indicate accessibility only and the quality and quantity of the services may not be as per norms in some cases.

33. As per assessment made by the Central Pollution Control Board in Class I cities and Class-II towns during 2003-04, about 26,254 MLD of wastewater was generated in 921 Class I cities and Class II towns in India (housing more than 70 percent of urban population). The wastewater treatment capacity developed so far is about 7044 MLD – accounting for 27 percent of waste water generated in these two classes of urban centres. Most of the cities have only primary treatment facilities. Thus, the untreated and partially treated municipal wastewater finds its way into water sources leading to pollution.

4. Institutional and Policy Framework in India

34. Under the Constitution of India, water supply and sanitation is a State subject. Urban Local Bodies (ULBs) have the responsibility for planning, design, implementation, operation and maintenance of water supply and sanitation services in cities and towns. At the Central level, the Ministry of Urban Development is the nodal agency for formulation of policies, strategies and guidelines and assists the States by providing financial assistance for the development of urban water supply and sanitation schemes in cities and towns. The Central Public Health and Environmental Engineering Organization (CPHEEO) is the technical arm of the Ministry and assists in preparation of policy guidelines, technical manuals etc. related to urban water supply and sanitation.

35. To achieve 100 per cent population coverage for sewerage, sewage treatment and low cost sanitation facilities in urban areas during Eleventh Plan, the following steps have been identified:

(i) Install more plants to treat, recycle and reuse sewage.

(ii) Industrial and commercial establishments must reuse and recycle treated sewage to reduce fresh water demand.

(iii) ULBs should amend their by-laws to make it mandatory for all residents to connect their toilets to the existing sewerage system.

(iv) Fringe areas of cities and colonies of economically weaker sections and slum dwellers be covered with low cost sanitation facilities, either on individual household basis or community basis with "pay and use system" with adequate maintenance arrangements. Necessary penal clause to be enforced effectively to stop open defecation practice as well as indiscriminate throwing of garbage/litter in public places.

(v) Targeted subsidy may be given to urban poor for taking water supply/sewerage house service connections, metering, and to construction of toilets.

(vi) Comprehensive storm water drainage system should be developed in all cities and towns in order to avoid water logging during monsoon.

36. *National Urban Sanitation Policy*. The Government of India, in discussion with the States, constituted a National Urban Sanitation Task Force in 2005 comprising eminent policy makers, practitioners, experts and NGOs in order to take stock of the situation and formulate a policy to comprehensively deal with the challenges in urban sanitation in Indian cities. Based on the recommendations of this task force, a National Urban Sanitation Policy has been approved by the Government of India in October 2008. The main elements of the policy are discussed below.

37. *Policy Vision and Goals*. The vision of the policy is that all Indian cities and towns become totally sanitized, healthy and livable and ensure and sustain good public health and environmental outcomes for all their citizens with a special focus on hygienic and affordable sanitation facilities for the urban poor and women. The policy articulates the following goals:

(i) Awareness Generation and Behavioral Change:

- Generating awareness about sanitation and its linkages with public and environmental health amongst communities and institutions
- Promoting mechanisms to bring about and sustain behavioral changes aimed at adoption of healthy sanitation practices

(ii) Open Defecation Free Cities: The ultimate objective is that all urban dwellers will have access to and be able to use safe and hygienic sanitation facilities and arrangements so that no one defecates in the open. In order to achieve this goal, the following activities shall be undertaken:

- Promoting household access to safe sanitation facilities (including proper disposal arrangements)
- Promoting community-planned and managed toilets wherever necessary, for groups of households who have constraints of space, tenure or economic constraints in gaining access to individual facilities
- Adequate availability and 100 per cent upkeep and management of public sanitation facilities in all urban areas, to rid them of open defecation and environmental hazards

(iii) Integrated City Wide Sanitation. Re-orienting institutions and mainstreaming sanitation by

- Mainstreaming thinking, planning and implementing measures related to sanitation in all sectors and departmental domains as a cross-cutting issue, especially in all urban management endeavors
- Strengthening national, state, city and local institutions (public, private and community) to accord priority to sanitation provision, including planning, implementation and Operation & Maintenance (O&M) management
- Extending access to proper sanitation facilities for poor communities and other un-served settlements

(iv) Sanitary and Safe Disposal: 100 per cent of human excreta and liquid wastes from all sanitation facilities including toilets must be disposed-of safely. In order to achieve this goal, the following activities shall be undertaken:

- Promoting proper functioning of network-based sewerage systems and ensuring connections of households to them, wherever possible
- Promoting recycle and reuse of treated waste water for non-potable applications, wherever possible, will be encouraged
- Promoting proper disposal and treatment of sludge from on-site installations (septic tanks, pit latrines, etc.)
- Ensuring that all the human wastes are collected safely confined and disposed-off after treatment so as not to cause any hazard to public health or the environment

(v) Proper Operation and Maintenance of all Sanitary Installations:

- Promoting proper usage, regular upkeep and maintenance of household, community and public sanitation facilities
- Strengthening Urban Local Bodies (ULBs) to provide or cause to provide, sustainable sanitation services delivery

B. Current Situation of Sewerage System in NCR

38. Status of Sewerage: A review of Regional plan 2001, done in 1999 revealed that only 20% towns of NCR were having partial sewerage system while the rural areas did not have any access to such facilities. The rivers (mainly Yamuna) and various seasonal streams had been converted into Nallas which carry untreated sullage and sewage polluting downstream areas. Recent studies reveal that barring Delhi, where 80% population is covered under sewerage and 1500 MLD waste water is being treated, the sewerage coverage cover ranges from 30-70% in UP and 60-80% in Haryana in the central NCR (CNCR) towns only. Among the CNCR towns, treatment facilities are available in Faridabad, Gurgaon, Ghaziabad and NOIDA. No sewage treatment facility is available in any of the priority towns of UP Sub-Region or Rajasthan sub-Region. Coverage of sewerage system in various priority towns ranges from 40% to 70% in Haryana, 3% to 5% in Rajasthan and 0% to 30% in Uttar Pradesh. The overall picture is dismissal. High incidence of water borne disease in NCR is indicative of the poor state of sanitation in the region.

39. System drawbacks and lack of coverage: The expansion of sewerage network has lagged far behind the growth of population resulting in overflow of sewage into drains causing river pollution or creation of cess pools in low lying areas of the town/settlements. There are imbalances in the overage of municipal sewerage systems in various parts of the cities. Significant portion of the city population living in marginal settlements, unauthorized colonies and urban villages etc has been devoid of regular municipal sewerage systems. In old cities like Delhi, sewerage system of the walled city is quite old and overloaded, which requires phased replacement or rehabilitation.

40. Development authorities who are associated with development of new areas in various towns/cities tend to take care of sewerage system in newly developed sectors only. Mostly comprehensive planning is not done and sewage treatment plants are not provided. Provision of sewerage system and treatment facilities in the existing areas is considered as the sole responsibility of the local bodies which have neither sufficient financial resources nor appropriate technical staff to provide such facilities. They are totally dependent upon the State Government for this, whose resources are also limited.

41. *Lack of Operation & Maintenance and Management Effort*. Poor maintenance of the sewerage system by the local bodies and development authorities has resulted in blocking of overflowing of sewers, open manholes and back-flows. The inadvertent act of throwing street sweepings and garbage by street sweepers into manholes/ open drains result in blocking of sewers and creates cess pools resulting in environmental degradation, foul smell and disease. Re-densification of population in the existing townships and lack of proportionate improvement in sewerage system have resulted in overflowing of sewers and manholes due to insufficient carrying capacity of sewers, thus , resulting in environmental degradation of the towns. Age old system of cleaning of sewers is still followed instead of use of modern machines like jetting cum suction machines, which are quick and do not damage the skin of the sewers, which is one of the main causes of subsidence of sewers (Source: Regional Plan 2021).

4. PROFILE OF HAPUR TOWN

A. Physical Features

42. Hapur Town is administratively part of Ghaziabad District in Uttar Pradesh State, and is an important town of National Capital Region. Geographically it is situated at 28^0 44' N latitude and 77^0 47' E Longitude (**Map 4-1**). It is well connected with important cities of country. National Highway 24 (Delhi-Lucknow-Muradabad Road) and National Highway 18 (Meerut-Bulandsahar Road) passes through Hapur city. The main Rail Line of Delhi-Lucknow-Howra also passes through Hapur Town. Hapur city is situated at about 54 Km east of Delhi, 32 Km from Meerut, 39 Km from Bulandsahar and 432 Km from the State Capital, Lucknow.

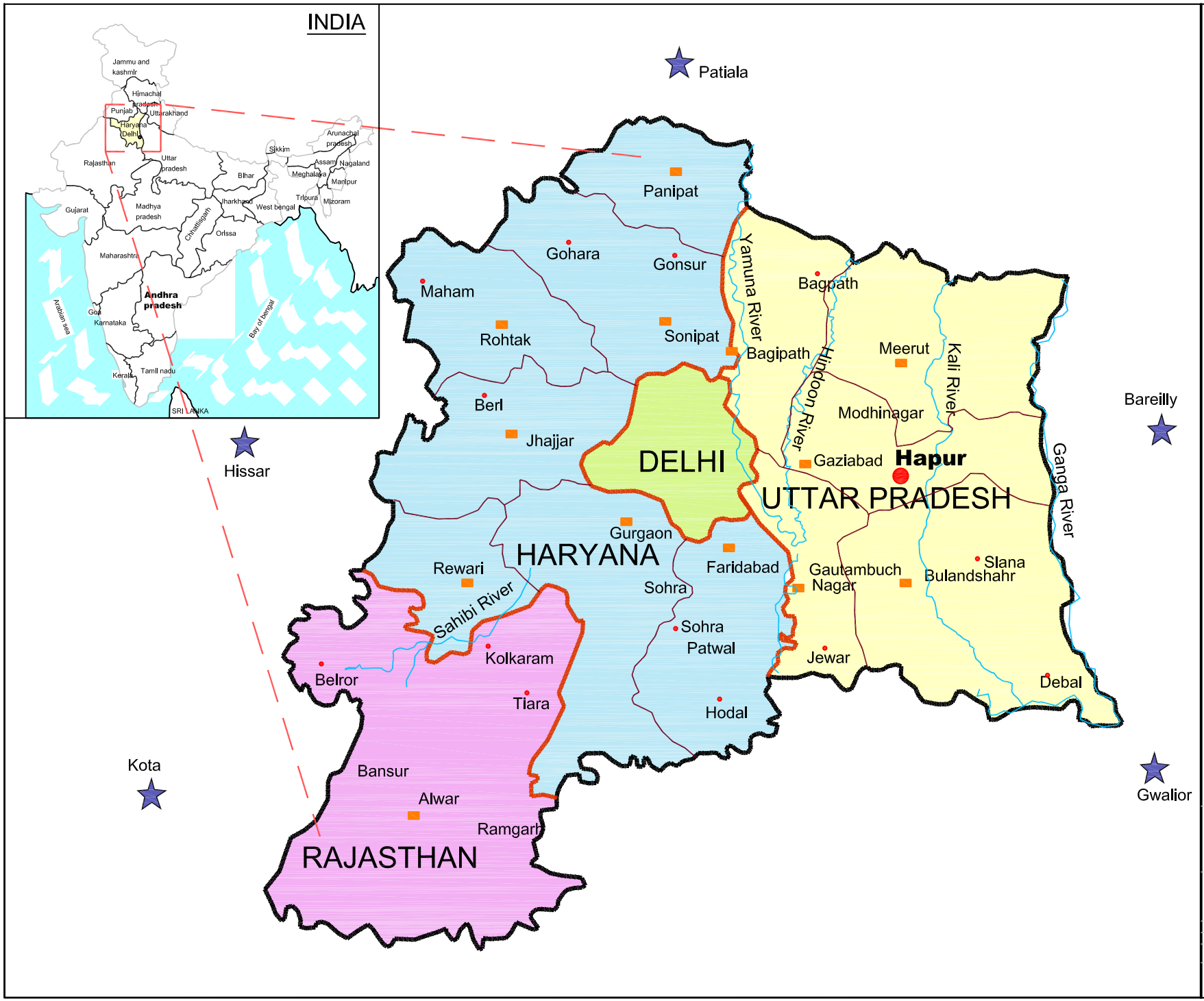
43. There are many stories around establishment and the name of Hapur. It is said that Hapur was established by King Harischandra. Some say, Shree Haridutt of Meerut/Bulandsahar established it and gave the name of Haripar. The word Hapar means garden and so the name of city is Hapur. In the 19th century a French General name Pairan appointed by Marathas started distribution of financial assistance to retired and incapacitated persons. British used this city traditionally for many years to provide land to retired and incapacitated persons after clearing forest bushes. In the year 1805, Tahasildar of Hapur Ibrahim Ali saved and protected the town from an attack by Aamir Khan Pindary. During 1857 at the time of India's struggle for independence Walidad Khan of Malagarh planned invasion of this city but because of resistance of Jats of Bhadhona it was not successful.

44. The city was surrounded all around by a wall with five gates- Dehli, Meerut, Garh Mukteshwar, Kothy and Sikandra. However, now none of these exists except some remnants. Jama Masjid in the town was constructed in the year 1670 during the rule of Emperor Aurangazeb.

45. The population of Hapur Town as per census 2001 was 211,983. Hapur Municipality (Hapur Nagar Palika Parishad) was established in 1982. At present, the municipal area of Hapur is 1,401 ha (14 sq. km).

1. Climate

46. Typical humid subtropical climate of north India prevails in Hapur, with high variation between summer and winter temperatures and precipitation. Summer starts early April and peaks in May. Winters are from November to February/March. The average temperature ranges from a minimum of 1.8°C to a maximum of 44.9°C; occasional extremes may in the ranges of 0.6°C to 47°C. Predominant winds are from north, northwest and west, followed by east and southeast. Extreme temperatures have ranged from −0.6 °C (30.9 °F) to 47 °C (116.6 °F). Annual average rainfall of the town is 732 mm.



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Regional Setting of Hapur

Legend

- NCR
- State Boundary
- District Boundary
- District Hq.
- Counter Magnet Areas
- River / Stream

Client:
Asian Development Bank
National Capital Region Planning Board

Consultant:
Wilbur Smith Associates

Drawn: Roopa	Checked: NSS
Date: April. 2010	Approved: NSS
Scale: NTS	

Map 4-1

2. Topography

47. The town has almost flat topography except a small portion in the south, which is a marginally higher than the general ground level. The general slope of the town is from north to south. The difference between the maximum and minimum ground levels is about 3 m - varies from 213 to 210 m above mean sea level. The depth of groundwater in the town varies from 9-12 m. The town is located in the catchment area of the Ganges River, the most important and perennial river of India, flowing at a distance of 30 km east of the town. River Kali, a tributary of River Ganges, flows in the eastern outskirts of the town in the north-south direction. Hapur Town drains into this Kali River. The general nature of the soil is sand mixed with clay.

B. Socio Economic Conditions

48. Hapur is an important commercial centre. It is an important town in NCR area, which is being developed to decongest National Capital Delhi by improving infrastructure in NCR towns with the aim of shifting some of the offices and establishments of Government of India. It is a big mandi of Grains, Gur, and Potato etc. Six big silos of grains owned by the Ministry of Food and Agriculture of the Government of India, exist in the town. Small to medium industries manufacturing sewing machines, motor spare parts, all type of agricultural machinery & equipments, oil expellers etc. have already developed in the town. Due to enormous growth of potatoes in the area around, there are many cold storages in the town. The town has all modern amenities like transportation, electricity, telephone – landline as well as mobile, water supply, sewerage etc. the town has many technical institutions, degree colleges, intermediate colleges, tehsil office, post office, fire station etc. For all the above-mentioned reasons and its strategically important location, Hapur is a fast developing town.

49. The main occupation of inhabitants is agriculture and agro based trade and business. Therefore, the people, specially farmers and traders are generally well to do. The importance of this town is steadily increasing. Economic conditions of the people are similar to those of any average Indian small town. There are double storied houses also in the town apart from single storied pucca & kuchcha houses.

50. *Urban Economy*. Hapur is an important centre for trade and commerce in western UP sub-region. The workforce participation rate is almost constant but the size of work force in the city has maintained its increasing trend as shown in the following **Table 4-1**.

Table 4-1: Population and Workforce of Hapur

S.N.	Year	Population	Work Force	WFPR	Male Workers %
1	1971	71,266	18,123	0.25	96.7
2	1981	10,2837	26,585	0.26	95.5
3	1991	14,6591	36,648	0.25	94.0
3	2001	21,1983	72,983	0.34	93.0

Source: Master Plan 2005; Census of India 2001,

C. Water Supply System in Hapur

51. *History of water supply system*. The existing water supply in Hapur Town was first introduced in the year 1955 on the basis of the scheme prepared in the year 1952 – 53 at an estimated cost of Rs.1.15 million. The scheme was designed for population of 5,500 at the rate of water supply of 135 LPCD. With the increase in population and consequently greater demand of water, the water supply arrangements fell short of the requirements. Therefore, a water supply reorganization scheme was prepared by LSGED in the year 1971 – 72 at an estimated cost of Rs.2.74 million. In this scheme, the town was proposed to be divided into three water supply zones. The boundaries of zone II were fixed such that the existing tube wells and overhead tank were sufficient to meet out the water demand of this zone, even at the enhanced rate of water supply of 180 LPCD. Provision of 1350 KL capacity overhead tank and 3 no. tube wells was made for zone I. Similarly for zone III, 1250 KL capacity overhead tank and 3 no. tube wells had been proposed. The provision of reorganization of the distribution system in the zone I and zone II had also been made in this scheme.

52. *Present System*. At present about 60 percent population that is about 150,000, is covered with water supply. The present rate of water supply in the town is about 100 LPCD. There are 18 tube wells for water supply, about 40 percent are directly connected to distribution system and remaining are feeding in three areas, where water is supplied through over head reservoirs. At present water supply is one hour a day from 6 AM to 7 AM.

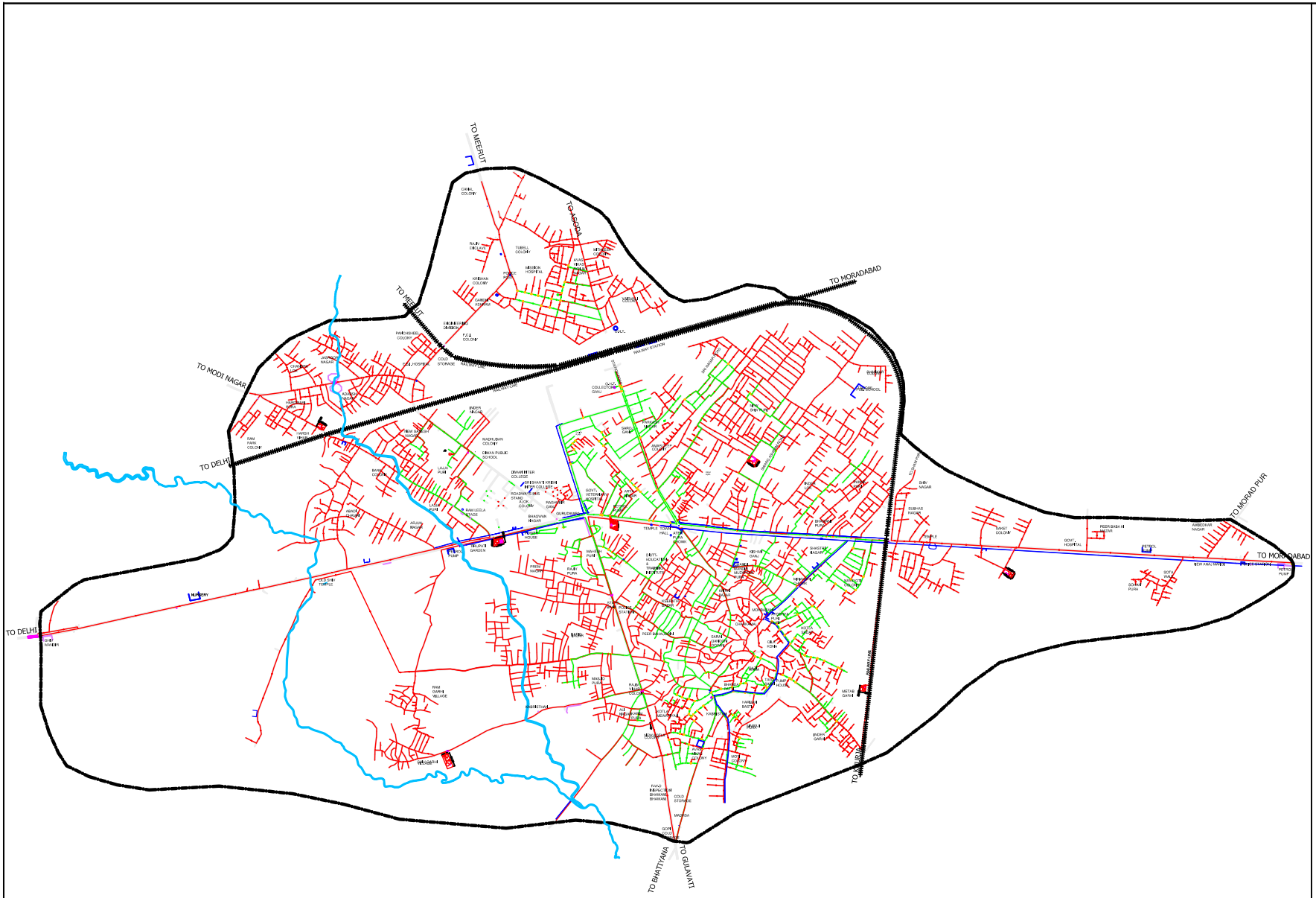
53. Ground water is available in sufficient quantity at shallow depth and as such is source of water supply. The ground water table depth is at 9-12 meter. The pumps on tube wells are of 30-60 HP. There are 5 overhead tanks (Total storage capacity 3,675 KL) spread in 5 water supply zones. In distribution system PVC pipes are laid. The chlorination is through liquid chlorine since last 10-15 years. All water connections are un-metered including commercial and industrial connections. The present water tax is being realized at the rate of 10 percent of annual rental value and water charges for domestic and non-domestic /commercial house connections are Rs. 50 and Rs. 75 per month respectively. In total there are 14,000 house water connections, 150 public stand posts, 810 hand pumps.

54. *Quality and quantity of Ground Water***.** Hapur is located in Central Gangetic Alluvium of quaternary age. The alluvium comprises of clay mixed kankar and fine and medium sand. The ground water in the area occurs under the unconfined to semi confined conditions. As per the subsurface configuration study of the nearby area, the saturated/tapped granular zones occur between the depth ranges of 70 - 100 meter below ground level. Yield of tube wells is 750-1,000 LPM. Depth of tube wells is about 110 meters. As per study and evaluation of chemical analysis results, it has been found that the formation water of upper and middle aquifer is potable. The chemical analysis results of the tube wells upto the depth of 110 meter below ground level indicate fresh/potable water.

55. *Institutional Arrangement for Water Supply.* Hapur Municipality is operating and maintaining the water supply system in the city. EE Project Division, UP Jal Nigam is in charge of all Water Supply and Sewerage capital works of Hapur and Bulandsahar towns.

56. *Projects under Consideration for Water Supply*. To meet the requirements of the year 2034-(projected population 425,331 for year 2034, 343,507 for year 2024 and 248,771 for year 2009), Reorganization scheme for water supply of Hapur City has been prepared by UP Jal Nigam. The scheme covers whole of the habitated area of Hapur Municipal Corporation admeasuring, 1,401 hectares. The scheme is estimated to cost Rs 324.5 million. The project proposes construction of new tube wells, over head tanks and pumping stations. Construction of new tube wells will be staggered in three stages; in first phase requirement of year 2009 will be met; in phase II, requirement of year 2024 will be met and in the 3rd phase ultimate requirement of the year 2034 will be met. It is proposed to supply water at the rate of135 LPCD and additional provision of 15 percent for losses in the system has been accounted. The project has been approved by GOI under UIDSSMT and is under implementation.

57. Existing and proposed water supply system is shown in **Map 4-2**.



Capclty Development of the NCRPB: Component B (ADB TA-7055)

Hapur
Existing & Proposed
Water Supply System

Legend

- Municipal Boundary
- Road
- Railway Line
- Existing Drain
- Water Course

Overlay Legend

- Exlstlng Lne
- Proposed Line
- Rlslng Maln
- Proposed O.H.T
- Exlstlng O.H.T
- Interconnection

Source: UP Jalnigam

Client:
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates

Drawn:SK	Checked: NSS
Date: Apri. 2010	Approved: NSS
Scale: NTS	

Map 4-2

5. EXISTING SEWERAGE SYSTEM IN HAPUR

A. General

58. Sewerage system in city was developed by UP Jal Nigam during year 1972-1974. The map of existing sewerage system showing trunk mains, sewage pumping station and laterals is given in **Map 5-1**. The present sewerage system exists in about 30 percent area of the old town and is almost defunct. Municipal authorities maintaining the sewerage system informed that the existing sewers are choked and over-flowing in number of areas. The sewage flow is so less that at present pumping is done for 2 hours a day and that too with one pump operating against installation of four pumps. This also indicates that most of the sewers are choked or connected to drains.

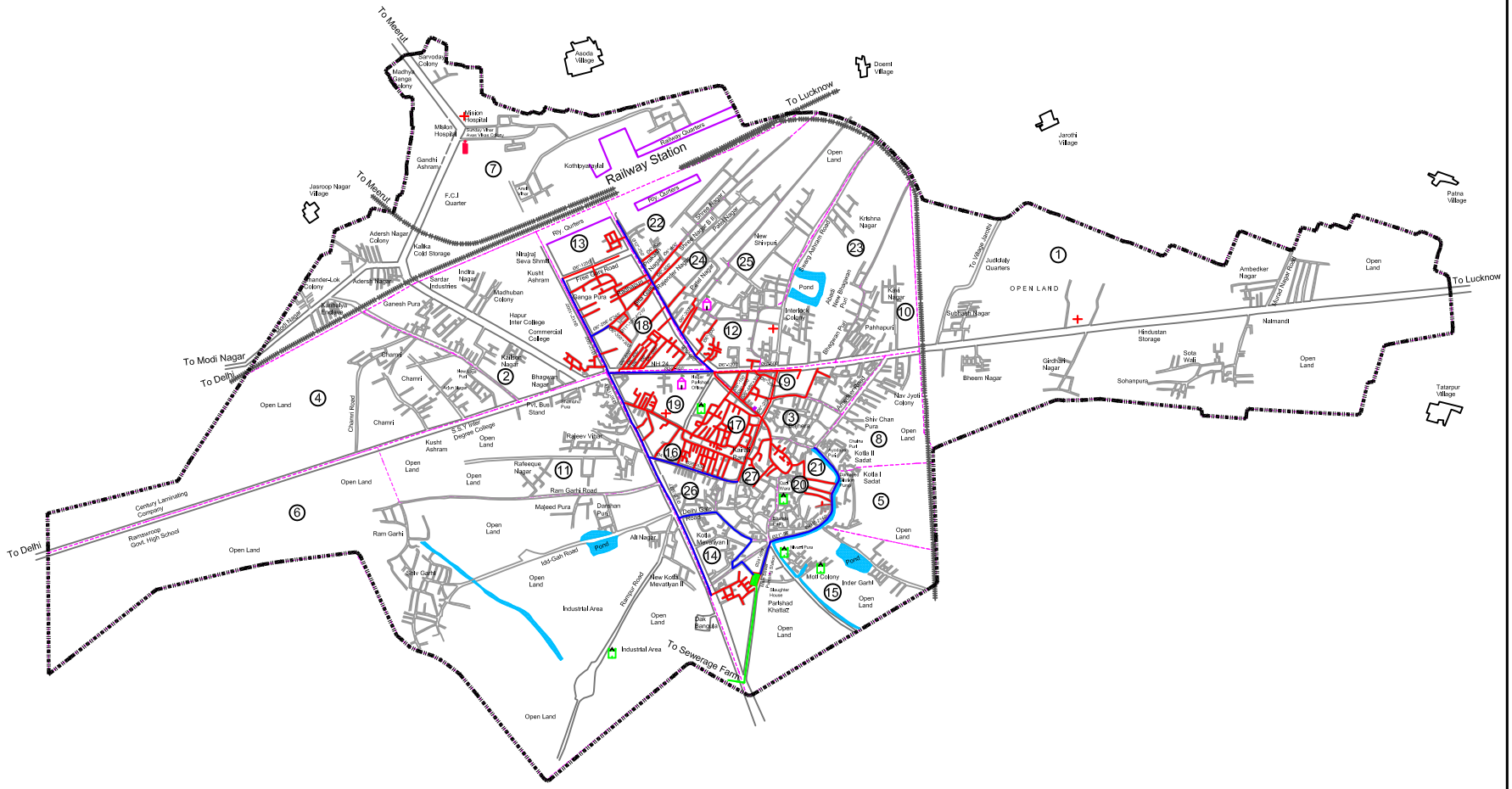
B. Sewer Lines and Pumping

59. *Sewer Lines*. Existing sewer lines are of RCC (Reinforced Cement Concrete), with a minimum diameter of 150 mm (lateral sewers) to a maximum of 850 mm. Total length of sewer line in Hapur is about 15 km. Of the 27 wards, sewers were laid in 11 wards partly (ward no,s 9, and 12 to 22).There are four main/trunk sewers laid to convey sewage collected through laterals to the Sewage Pumping Station (SPS) and then to the sewage farm. Diameter of these sewers varies from 300 mm to 850 mm .

60. Most of the sewer lines are blocked and are overflowing. Due to blockages in the system, most of the sewers are discharging sewage into open drains. Almost all of the open drains in the congested city area are carrying sewage. As a result, the total sewage reaching the sewage pumping station is very minimal. At present pumping is done for 2 hours a day with one pump operating against installed capacity of four pumps. The sewage reaching sewage pumping station is hardly 5-10 percent of design flow; which confirms that the existing sewerage system is almost defunct.

61. *Sewage Pumping Station*. As part of the system a Sewage Pumping Station was developed near Awas Vikas Colony (Ward 15), along Circular Road. The sewage that reaches SPS through trunk sewers is pumped for sewage farming There are four open clog turbine pumps of capacity 30 KW each. The electric motor is of 960 RPM rated 55 Amperes. The Mechanical and electrical equipments are in use for almost 30 years, and needs immediate replacement.

62. *Rising Main*. A rising main – of 450 mm diameter, partly of Cast Iron, and partly of RCC, was laid from SPS to agriculture farms in the south of the town.



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Hapur
Existing Sewerage System

Legend

- Municipal Boundary
- Major Roads
- Minor Roads
- Railway Line
- Masjid
- Temple
- Church
- Hospital
- Water Course

Overlay Legend

- Existing Trunck Sewer
- Existing Lateral Sewer
- RIsIngmaIn
- Sewage Pumping Station
- Ward Boundary
- Ward Number (8)

Source:
Municipal Council Hapur

Client
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates

Drawn: SK | Checked: NSS
Date: April. 2010 | Approved: NSS

Scale: 00 15 300 450 600 750 Meters

Map 5-1

C. Sewage Treatment Plant

63. The sewerage system in Hapur was developed without a sewage treatment facility. Sewage pumped from SPS is used for irrigation in the surrounding agricultural fields without any treatment. There was a large demand for raw sewage from farmers, but due to urbanization, the farming activity has greatly been reduced, and at present there is no demand, and untreated sewage is disposed off directly. It was the practice of Hapur Municipality to sell the raw sewage to the farmers to generate some additional revenues.

64. Master plan 2005 has identified two sites for development of STP; however, these sites needs to acquired as they are under private ownership and are currently used for agriculture.

D. Institutional Arrangement

65. Sewerage system is maintained by Hapur Municipality. The capital works, rehabilitation, extension and up gradation in sewerage system is done by UP Jal Nigam. In Municipal Corporation, Assistant Engineer is in charge of the operation and maintenance of sewerage system.

E. Proposals for up gradation of Sewerage System

66. Earlier it was proposed to prepare sewerage scheme for Hapur under UIDSSMT. Accordingly UP Jal Nigam has done some work. Subsequently the state government took a decision to have sewerage schemes for District Head Quarter towns only in the first instance and accordingly the work of preparation of sewerage project was dropped by UP Jal Nigam. HPDA informed that they will take up the matter with the state government for giving relaxation in this regard looking to the fact that Hapur is under NCR and probably the only Non District HQ Town which has a Development Authority.

6. TOWN PLANNING POPULATION FORECAST

A. Overview

67. The Master Plan of development areas are prepared under UP urban Planning and Development Act 1973 and master Plan for regulated areas are prepared under UP Regulation of Building Operations Act 1958.

68. *Development Area*. The Government of Uttar Pradesh in 1978 declared the area falling under Hapur Municipality and 31 villages of Hapur and Meerut Tehsils as Hapur Viniyamit Area. Subsequently GOUP in 1993 extended area by including Pilkhua Municipal Area, Babugarh Nagar Punchayat and 51 villages. In 1998 Hapur Pilkhua Development Authority (HPDA) was created to implement Master Plan and area under Viniyamit Area. Some of the development area under jurisdiction of HPDA is shown in **Map 6-1**. Some more area near Garh Mukteshwar is also under HPDA but it is not connected to the area. The Master plans for Hapur and Pilkhua are prepared separately for next 20 years in which urbanisable area under Hapur and Pilkhua are presented and land use is scientifically defined so that urban growths are in desired manner. The Master Plan for Hapur for period 1979-2001 for target population of 200,000 in year 2001 was approved by GoUP in 1983. The regional plan NCR 2001 proposed population of Hapur in year 2001 as 450,000. To match it the Master Plan 2005 for Hapur was prepared considering population in the year 2005 of 450,000.

69. The Government of Uttar Pradesh in 1978 declared the area falling under Hapur Municipality and 31 villages of Hapur and Meerut Tehsils as Hapur Viniyamit Area. Subsequently GoUP in 1993 extended area by including Pilkhua Municipal Area, Babugarh Nagar Punchayat and 51 villages. In 1998 Hapur Pilkhua Development Authority (HPDA) was created to implement Master Plan and area under Viniyamit Area. The Master Plan for Hapur for period 1979-2001 for target population of 200,000 was approved by GoUP in 1983. The regional plan NCR 2001 proposed population of Hapur in year 2001 as 450,000 and as such the Hapur Master Plan 2005 was modified considering population in the year 2005 of 450,000. Now the master plan for next 20 years is under preparation. The master plan proposes land use plan for the city with the intention of achieving balanced distribution of various land uses.

70. *Land Use*. In 1994, Hapur had residential as the major land use (49.71 percent) followed by traffic and transportation (23.95 percent). Industrial land use (5.09 percent) was not a dominant land use in 1994. **Map 6-2** shows the proposed 2005 land use as per Master Plan, and land use details are given in **Table 6-1**.

Table 6-1: Comparative Land Use Pattern as in 1994 and as proposed in Master Plan 2005

S.No	Category	1994	2005
1	Residential	49.71	56.27
2	Commercial	11.20	3.81
3	Industrial	5.09	6.72
4	Govt-Semi Govt	1.08	1.14
5	Community Facility	0.92	2.07
6	Traffic & Transport	23.95	10.00
7	Recreation Open Spaces/Play Grounds/others	8.05	19.98
	Total	100	100

Source: Master Plan 2005

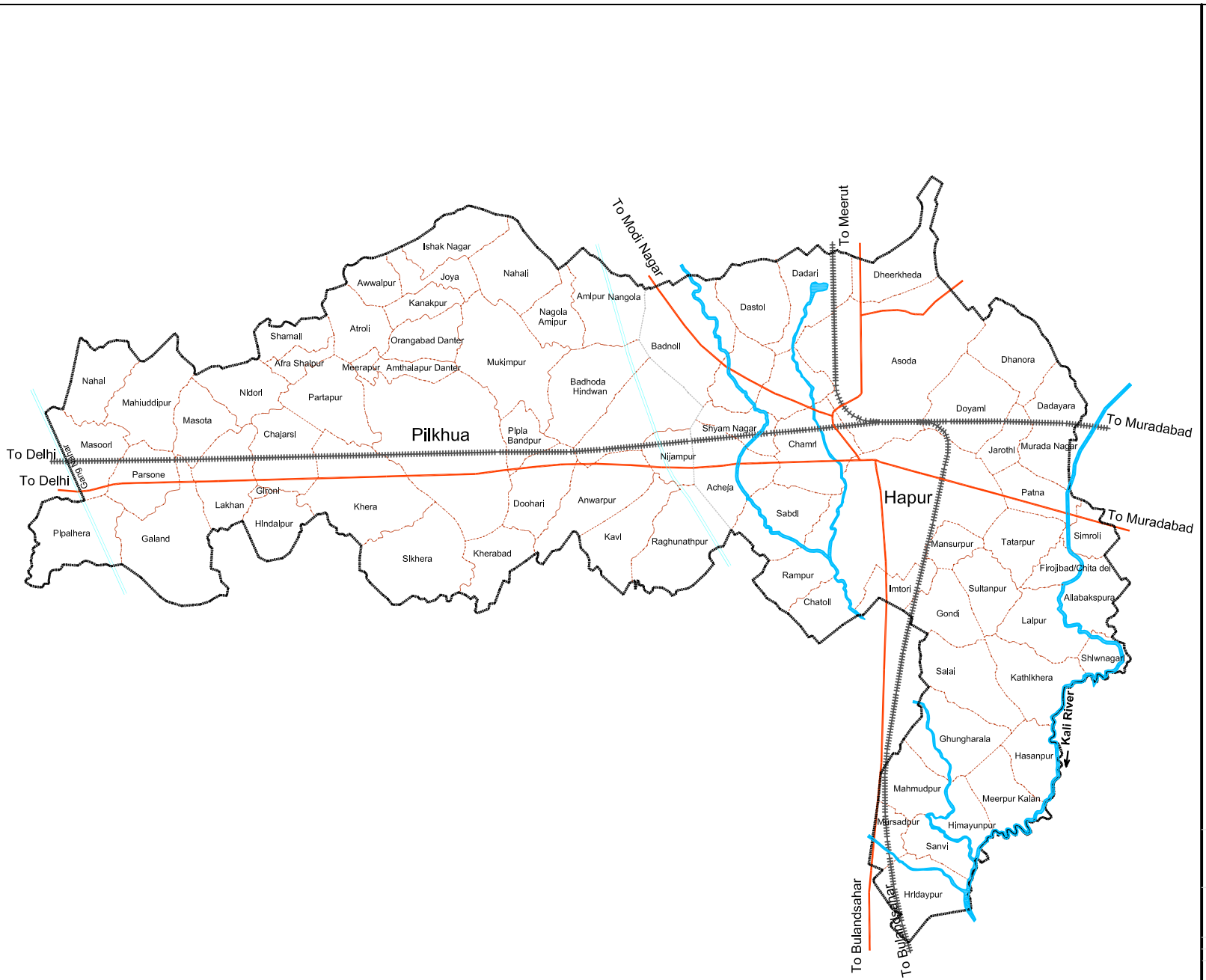
B. NCR Regional Plan

71. Regional Plan 2001 of NCR assigned population of 450,000 for Hapur in the year 2001. However actual population as per census 2001 of Hapur was 211,983. Thus the development was not as much as envisaged. The regional plan 2021 of NCR proposed six tier hierarchy of settlements, as given in the following **Table 6-2**.

Table 6-2: Proposed Six-tier Hierarchy of Settlements

S No	Hierarchical Level	Population Range
1	Metro Centre	1 million and above
2	Regional Centre	0.3 to 1 million
3	Sub-Regional Centre	50,000 to 0.3 million
4	Service Centre	10000 to 50000
5	Central Village	5000 to 10000
6	Basic Village	Below 5000

Source: NCR Regional Plan 2021



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Hapur
HPDA Development Area

Legend

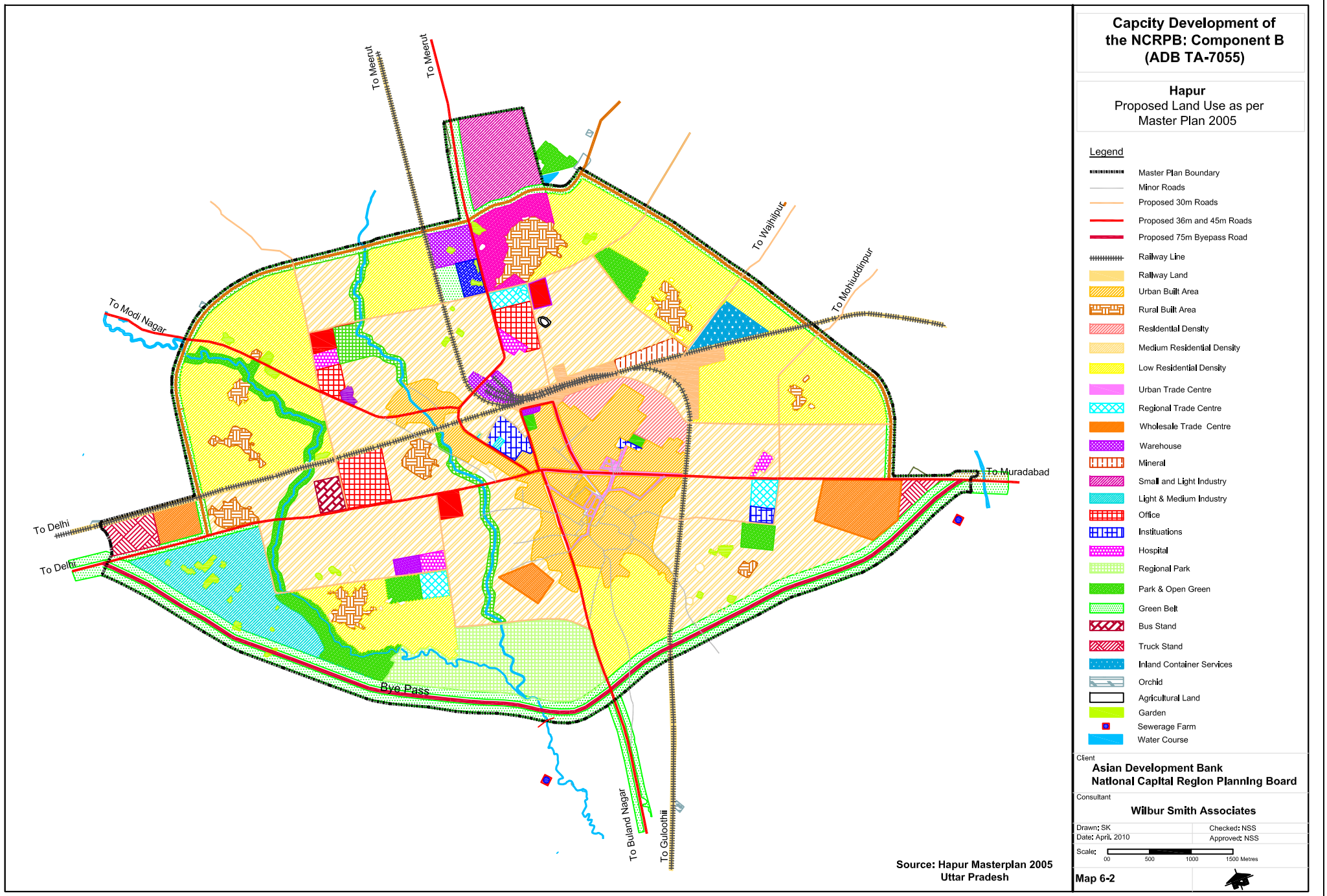
- Development Area Bounary
- Village Bounary
- Existing Road
- Railway Line
- Canal
- Drain, River

Client
Aslan Development Bank
National Capital Region Planning Board

Consultant
Wllbur Smlth Assoclates

Drawn:SK	Checked: NSS
Date: April. 2010	Approved: NSS
Scale: NTS	

Map 6-1


To Meerut
To Meerut
To Wajhilpur
To Mohiuddinpur
To Modi Nagar
To Muradabad
To Delhi
To Delhi
Bye Pass
To Buland Nagar
To Gulothii
Source: Hapur Masterplan 2005
Uttar Pradesh
Capcity Development of the NCRPB: Component B (ADB TA-7055)
Hapur
Proposed Land Use as per Master Plan 2005
Legend
Master Plan Boundary
Minor Roads
Proposed 30m Roads
Proposed 36m and 45m Roads
Proposed 75m Byepass Road
Railway Line
Railway Land
Urban Built Area
Rural Built Area
Residential Density
Medium Residential Density
Low Residential Density
Urban Trade Centre
Regional Trade Centre
Wholesale Trade Centre
Warehouse
Mineral
Small and Light Industry
Light & Medium Industry
Office
Instituations
Hospital
Regional Park
Park & Open Green
Green Belt
Bus Stand
Truck Stand
Inland Container Services
Orchid
Agricultural Land
Garden
Sewerage Farm
Water Course
Client
Asian Development Bank
National Capital Region Planning Board
Consultant
Wilbur Smith Associates
Drawn: SK
Checked: NSS
Date: April. 2010
Approved: NSS
Scale:
00
500
1000
1500 Metres
Map 6-2

72. The Regional Plan 2021 also defined Central NCR (CNCR) and area of NCR except CNCR i.e. outside CNCR. Regional Plan 2021 proposed 7 metro centres and 11 regional centres. Regional Plan 2021 defined regional centre as, well established urban centre in the region, marked by highly specialized secondary and tertiary sector activities and providing job opportunities, which normally cannot be performed by other lower order centres. The regional centres will be developed for advanced industrial and other economic activities and will have concentration of administrative and higher order service functions, which are expected to exert an increasingly dynamic influence on attraction of investment and creation of conducive living and working environment. In Regional Plan 2021 Hapur-Pilkhua has been proposed as regional centre outside CNCR and population estimated is as follows: 300,000 in 2011 and 450,000 (2021).

C. Population Projections

73. The population of Hapur has increased from 146,591 to 211,983 during 1991-2001. The town is mainly developing on both sides of Bulandsahar road towards Bulandsahar in narrow width and along Delhi- Muradabad National Highway towards Muradabad. HPDA is developing all areas in south west direction lying between Bulandsahar road and NH 24. Census data of Hapur for year 1951to 2001 are given in the following **Table 6-3**.

Table 6-3: Population Growth of Hapur

Year	Population	Decadal Population Growth Rate (%)
1951	49,260	12.2
1961	55,248	29.0
1971	71,266	44.3
1981	102,837	42.2
1991	146,262	42.2
2001	211,983	44.9

Source: Census

74. Based on decadal populations, the future population has been projected in **Appendix 2** as per different prevalent methods such as arithmetical increase, Incremental increase, geometrical increase, graphical method etc. Considering high growth proposed under regional plan geometrical increase method has been adopted for estimating future population as it gives more population than that by other methods. Moreover the population projected by geometrical increase method resemble closely to Regional Plan 2021 population projection. The regional plan projected population as available in the plan is combined for Hapur and Pilkhua, separate population projection for Hapur not given, as such exact match is not done. The projected population as adopted is given in the following **Table 6-4**.

Table 6-4: Projected Population of Hapur

Year	Projected Population	Decadal Population Growth Rate %
2001	211,983	-
2011	278,143	31.2
2021	364,951	31.2
2031	478,853	31.2
2041	628,302	31.2

Source: Analysis

75. *Projection of Population beyond Hapur Municipal Area and within Project Area*. The population of the area outside municipal boundary has been worked out by subtracting population residing in municipal area in 2041 from total population of Hapur of year 2041. On this basis the population density shall be as given in the following **Table 6-5**

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Table 6-5: Population Densities in Project Area

Location	Population year 2041	Area in ha	Population Density
Municipal Boundary	364,631	1,401	260
Area outside municipality but with in project area	263,671	3,232	84
Total Area	**628,302**	**4,633**	**134**

Source: Mater Plan

D. Projection of Ward Level Population

76. For Sewerage Planning it is most crucial to identify smaller sewerage zones covering the whole project area. For this purpose population of the sewerage zones is also required and this can be assessed if ward, the smallest unit of a ULB, is considered and hence the population of the wards needs to be projected for various design stages from 2011-41.

77. For projecting the ward population the available data is population of ward in year 2001Census. The population density in year 2001 has been calculated as area of ward is known. The population of Hapur as arrived by geometric increase for the year 2011, 2021, 2031 and 2041have been distributed in different wards as per assumed growth of each ward. Growth of wards will vary, the wards which are at peak density i.e. 700-800 persons per hectare will grow at a very slow pace but wards which are at minimum density at present will grow at maximum rate. Rate of growth has been adopted as per **Table 6-6**. Maximum density has been taken 800 persons/ hectare. Ward wise population for year 2011, 2021, 2031 and 2041 are given in **Appendix 3**.

Table 6-6: Assumed Decadal Growth in Population Density

Population Density Range (*persons/hectare)*	**Decadal growth** *(%)*
0-100	20
100-200	18
200-300	15
300-400	12
400-500	9
500-600	6
600-700	4
700-800	2

Source: Analysis

7. MASTER PLAN FOR SEWERAGE

A. Sewerage Master Plan for Hapur

78. Master Plan for sewerage system in Hapur was prepared in January 2009. This was done based on the available topographical details of city i.e. without doing additional engineering surveys and investigations. The salient features of the Master Plan are presented below.

79. *Broad Planning*. Waste water disposal systems can be either on-site or water borne in which wastes are disposed through pipe network off-site into a water body or on land. A mix of the two systems has been proposed here such that densely habituated parts of city are provided with sewerage system and outskirts of city with low density are provided with on site sanitation to economies the costs.

80. *Planning Year and Master Plan Area*. The project horizon year is 2041 and as such sewerage system has been planned for area of city to which it will grow by the year 2041. The present municipal council area is 1,401 hectares. The master plan 2005 boundary covers an area of 4,633 hectares. The projected population for year 2041at 628352 can be habituated in the Master plan area of 4633 hectares at an average density of 135.6 persons/hectare.

81. *Base Map Preparation*. To prepare the maps for planning sewerage system in the Hapur Town following maps/data were used:

(i) Topographical map Sheet 53 H 14/I from Survey of India (SOI) (surveyed 1971-72), scale 1:25,000

(ii) Existing Land Use map 2007 obtained from NCR cell UP Ghaziabad (**Map 7-1**)

(iii) Map of Hapur Municipal Area scale 1:4800 showing existing sewer lines proposed sewer lines and Wards, obtained from local municipal office, in hard copy

(iv) Water Supply Network Map obtained from UP Jal Nigam

(v) Master Plan Land Use Plan 2005

(vii) Sector maps of Preet Vihar Phase I, Preet Vihar Phase II and Anand Vihar from HPDA. This is given as **Map 7-2**.

82. *Constraints and strategies for planning sewerage in Hapur*. The area is sloping towards south and southwest. Topography of area is flat. This puts a constraint on collecting and carrying the sewage flows by gravity without pumping. The natural slope of the town will be followed while planning the sewer network in order to minimize pumping. Newly developing areas and areas anticipated to be developed would be considered in the planning. In narrow lanes, the sewers will be proposed in centre, so that houses on both sides of the road can be connected to it.

83. *Sewerage Zones*. The area which has natural slope towards south STP and near to south STP has been considered to drain in south STP and remaining area which is near to STP east is considered to drain in STP east. These two areas have been further sub divided as per existing sewerage system, municipal area to be covered on first priority and area being developed by HPDA which is also to be covered on priority. The other remaining area is not populated at present and not presently planned for development and as such has been considered separately and it has been further sub divided as per main physical boundaries such as rail line, NH, bye pass road.

84. The project area has been divided into 8 sewerage zones, named zone 1 to 8. The contour map shows that Meerut–Bulandsahar road is at contour of 213 m and area on west side of Meerut –Bulandsahar road drains towards east and south, lowest point being near proposed STP south which is at 210 m contour. The area on west of Meerut –Bulandsahar road is generally flat at contour of 213 m, but the lowest point is towards Tatarpur village where Kali river passes. The contour here is of 210 m. In the master plan 2005 two sites for STPs have been marked, one near Tatarpur village and on east side of city and is near to Kali River. Other site shown in the master plan is towards south near Chatoli village. These sites are suitable from engineering aspects as situated towards depression, low levels. The zone 1, 2, 3, 5 and 8 will drain in STP south and zone 4, 6, and 7 will drain in STP east. Proposed sewerage zones are shown in **Map 7-3**.

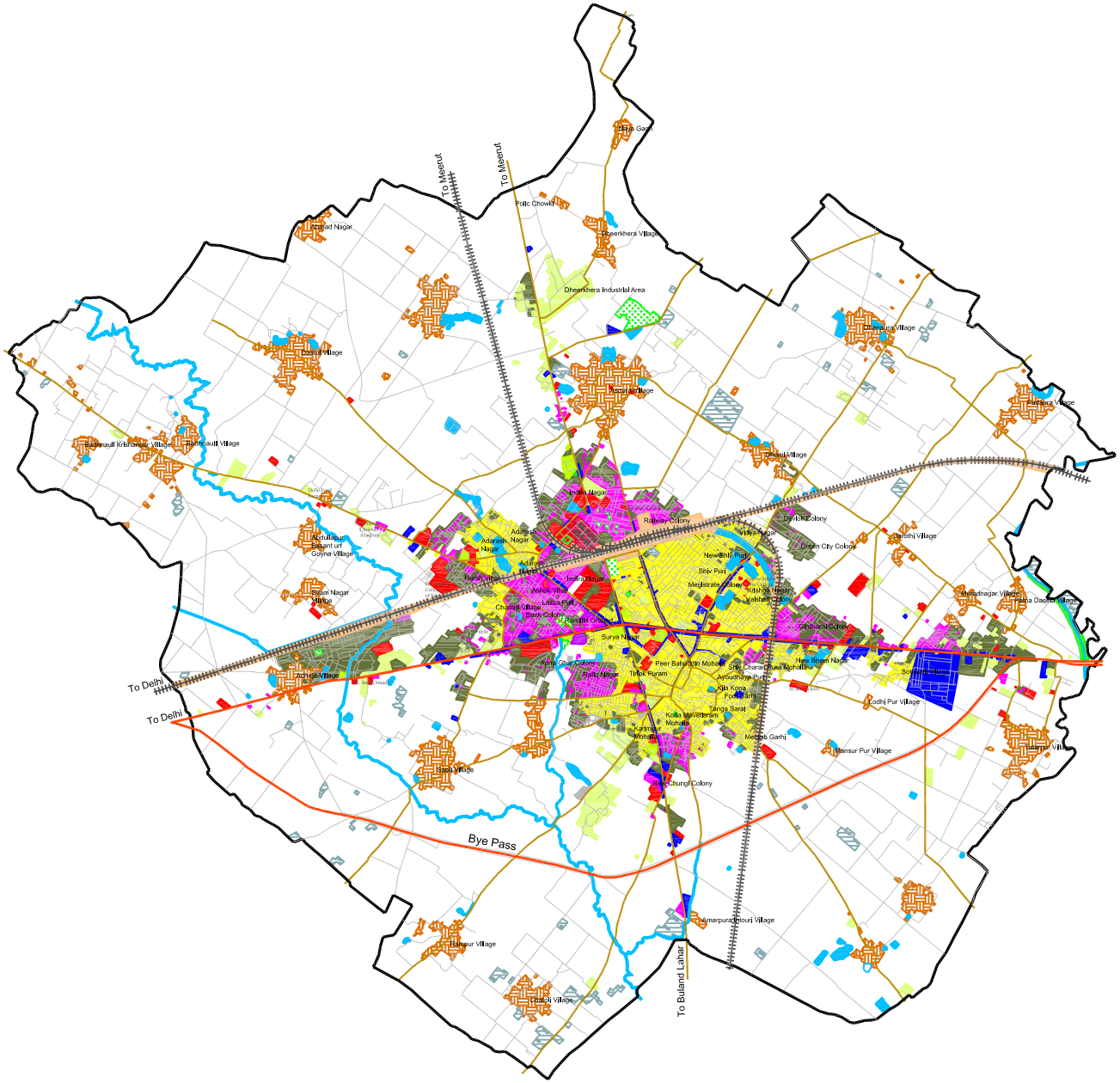
(i) Zone 1: It comprises of 9 sectors being developed by HPDA such as Preet Vihar, Anand Vihar etc. Its area is 1280 hectares. For some of the sectors HPDA has designed the sewers (**Map 7-4** and **Map 7-5**).

(ii) Zone 2: The area covers the existing sewered area of Hapur. Area is 180 hectares

(iii) Zone 3 & Zone 4: The remaining area of Municipal Corporation which is not covered under zone 1 & 2 is placed under zone 3 & 4 such that western part which will drain in STP south is named zone 3 and other area named zone 4. Area of zone 3 is 500 hectares and area of zone 4 is 360 hectares

(iv) Zone 5 & zone 8: Out of the remaining area the southern part which is near to STP south is classified as zone 8 and North east part of city which is more near to STP south as compared to STP east has been classified as zone 5. The area of zone 5 is 910 hectares and area of zone 8 is 640 hectares

(v) Zone 6 and zone 7: The remaining area which is near to STP east has been classified as zone 6 and 7. NH 24 divides zone 6 and 7. Area of zone 6 is 1090 hectares and area of zone 7 is 640 hectares



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Hapur
Existing Landuse - 2007

Legend

- Land Use Boundary
- National Highway
- Major Roads
- Minor Roads
- Railway Line
- Railway Area
- Rural Builtup
- Builtup
- Residential
- Commercial
- Storage Area
- Community Facility & Services
- Offices
- Industry
- Transportation
- Parks, Play Ground
- Open Spaces
- Orchid
- Green Belt
- Cremation & Graveyard
- Agricultural
- Water Course

Source:
NCR Cell, UP

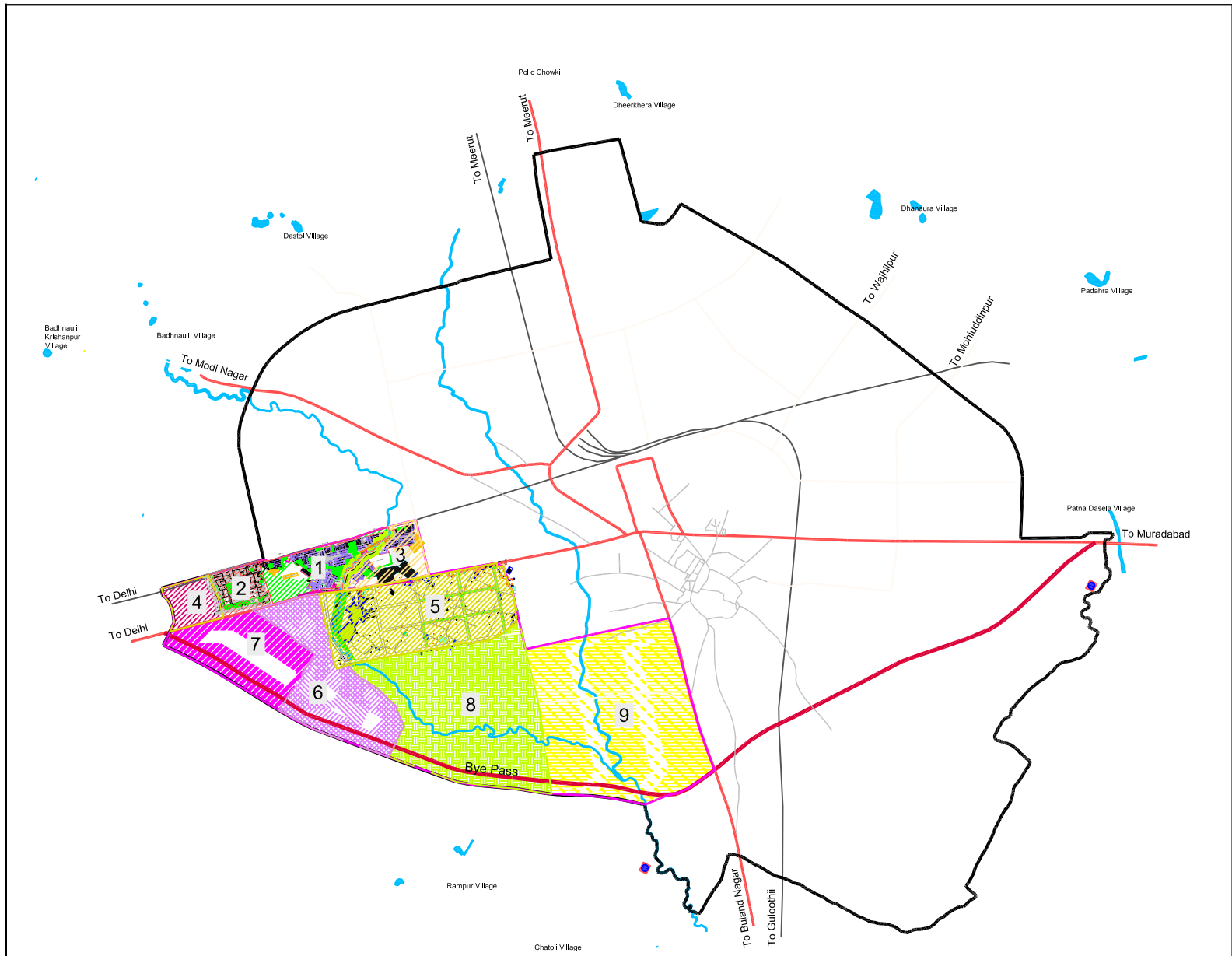
Client
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates

Drawn: SK | Checked: NSS
Date: April. 2010 | Approved: NSS

Scale: 00 320 640 960 1280 1600 Metres

Map 7-1



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Hapur
Preet Vihar, Anand Vihar and Other Sectors Under Development by HPDA

Legend

- Master Plan Boundary
- Minor Road
- Proposed 30m Road
- Proposed 36m and 45m Road
- Proposed 75m Byepass Road
- Railway Line
- Sewerage Farm
- Water Course

Overlay Legend

- Sector Boundary
- 1. Preet Vihar-I (Area=0.54 Sq. Km)
- 2. Preet Vihar - II (Area=0.28 Sq. Km)
- 3. Preet Vihar Extension (Area=0.41 Sq. Km)
- 4. Transport Nagar (Area=0.26 Sq. Km)
- 5. Anand Vihar - I (Area=1.65 Sq. Km)
- 6. Anand Vihar Extension (Area=1.17Sq. Km)
- 7. City Center(Area=0. 96Sq. Km)
- 8. Anand Vihar II (Area= 2.54 Sq. Km)
- 9. Leather City (Area= 3.09 Sq. Km)
- Manhole

Source: Information by HPDA

Client
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates

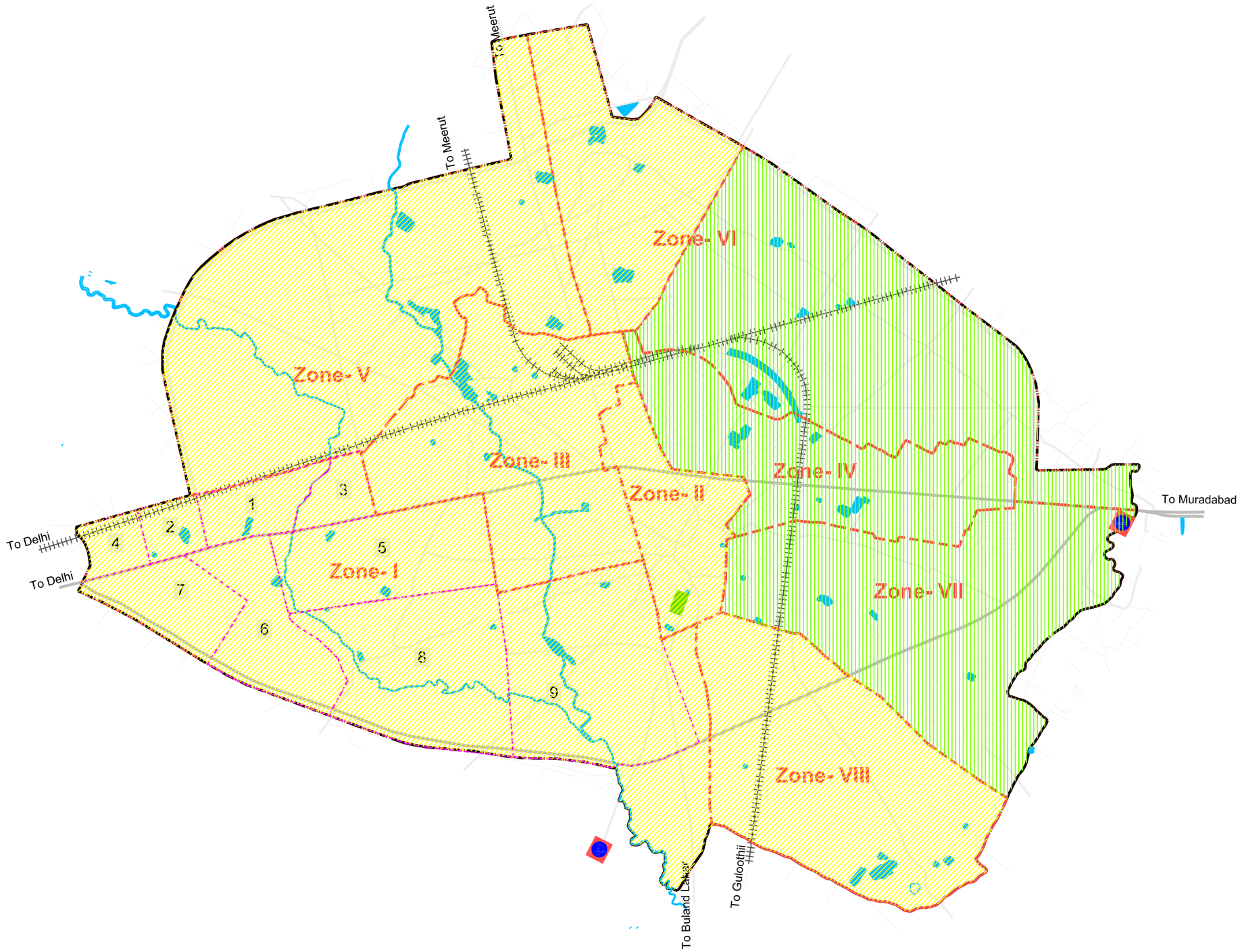
Drawn:SK	Checked: NSS
Date: April, 2010	Approved: NSS

Scale: 00 300 600 900 1500 Metres

Map 7-2

Capcity Development of the NCRPB: Component B (ADB TA-7055)

Hapur
Proposed Sewerage Zones



Legend

- Extended Master Plan Boundary
- National Highway
- Major Roads Existing & Proposed
- Minor Roads
- Railway Line
- Water Course
- Existing Pump House

Overlay Legend

- Zone Boundary
- HPDA Sector Boundary
- Zone- VI — Zone Number
- 6 — Sector Number
- Area Draining in South STP (Zone I,II,III,V & VIII)
- Area Draining in East STP (Zone IV, VI &VII)
- Proposed STP & Pump House

Zone Area:

Zone-I	12.8 Sq.Km
Zone-II	1.8 Sq. Km
Zone-III	5.0 Sq Km
Zone-IV	3.6 Sq.Km
Zone-V	9.1 Sq.Km
Zone-VI	10.9 Sq.Km
Zone -VII	6.4 Sq.Km
Zone-VIII	5.6 Sq.Km
Total Area	**= 55.2 Sq. Km**

Client

Asian Development Bank
National Capital Region Planning Board

Consultant

Wilbur Smith Associates

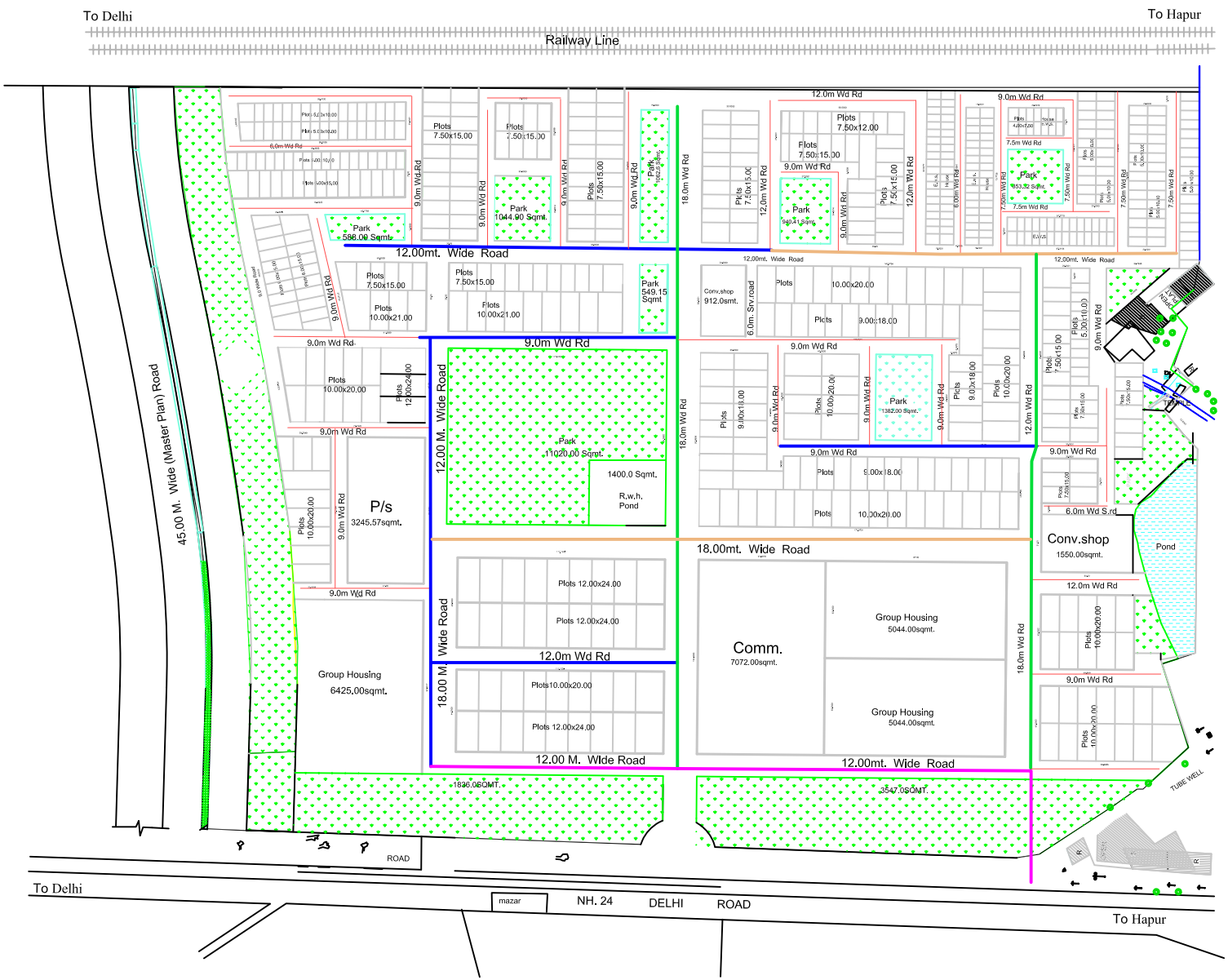
Drawn: SK	Checked: NSS
Date: April. 2010	Approved:NSS

Scale: 00 250 500 750 1000 1250 1500 Metres

Map 7-3

Capcity Development of the NCRPB: Component B (ADB TA-7055)

Hapur
Proposed Sewerage System in Preet Vihar



Legend

- Proposed 250mm Dia Pipe
- Proposed 300mm Dia Pipe
- Proposed 350mm Dia Pipe
- Proposed 400mm Dia Pipe
- Proposed 500mm Dia Pipe

Area Statement:

Total Area of Scheme	= 2,17,351 Sq.m. Or 21.73 Hect.
Area Under Master Plan Road	= 9,000 Sq.m. Or 0.90 Hect.
Area Under Master Plan Green	= 20,000.00 Sq.m. Or 2.00 Hect.
Net Area of The Scheme	= 1,88,351.00 Sq.m. Or 18.83 Hect.
Area Under Residential Plots	= 68,066.00 Sq.m. Or 6.80 Hect. 36.14%
Area Under Commercial	= 9,534.00 Sq.m. Or 0.95 Hect.5.06%.
Area Under School	= 3245.57 Sq.m. Or 0.32hact.1.72%
Area Group Housing	= 16513.00 Sq.m. Or 1.65hact.8.77%
Area Under Park & Green	= 32101.71sq.m. 3.21 Hect.17.04%
Area Under Roads	= 58890.72 Sq.m. 5.89 Hect. 31.27%

DETAIL OF PLOT SIZE

S.no.	Type	Size	Area	No.of Plots
1	A	12.0mx24.0m	288.0 Sqm	30
2	B	10.0mx20.0m	200.0 Sqm.	110
3	C	9.0mx18.0m	162.0 Sqm.	48
4	D	7.5mx15.0m	112.5 Sqm.	144
5	E	6.0mx15.0m	90.0 Sqm.	34
6	F	5.0mx10.0m	50.0 Sqm.	137
7	G	4.0mx7.50m	30.0 Sqm.	118
TOTAL PLOTS				621

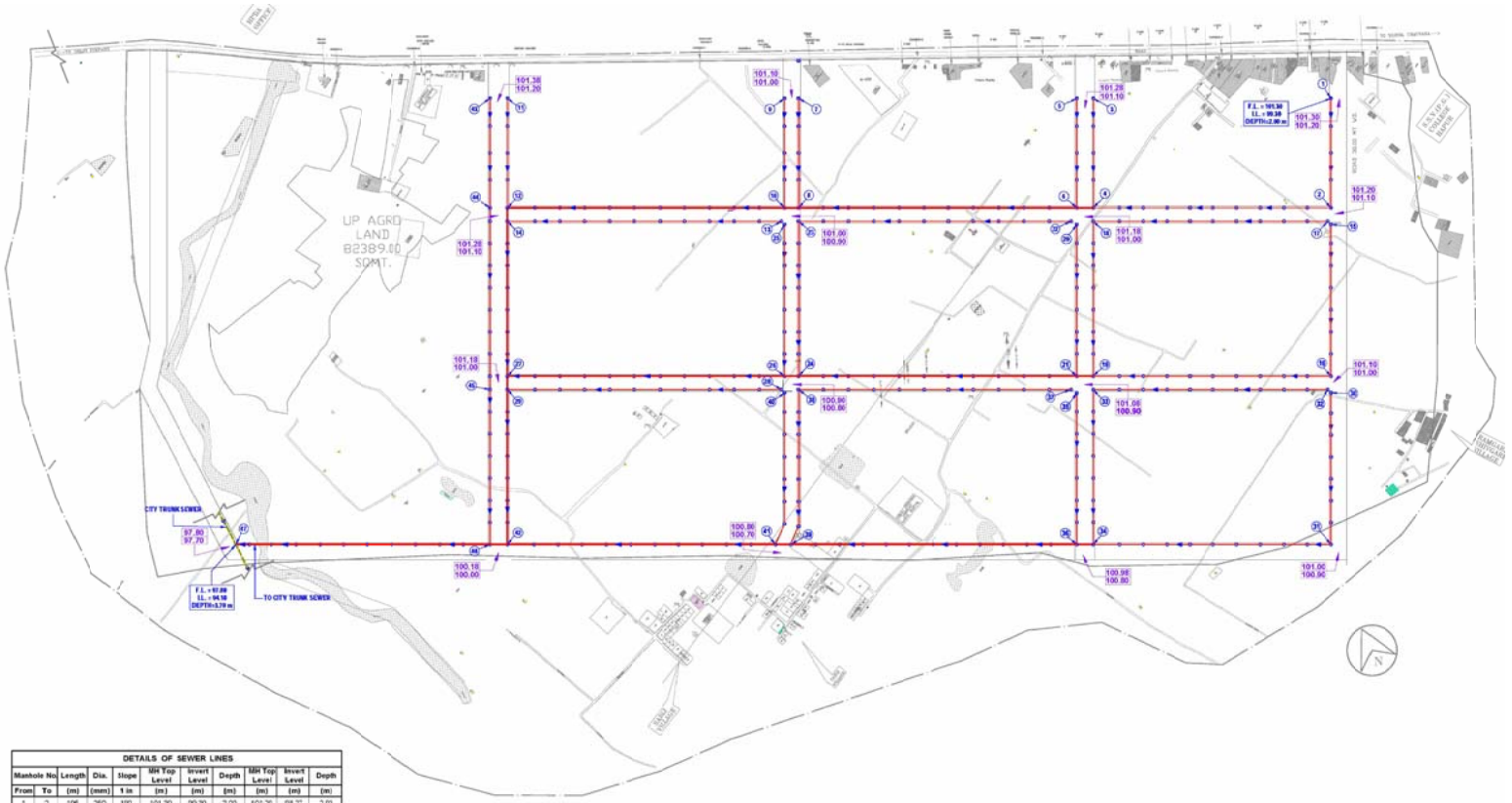
Client:
Aslan Development Bank
National Capital Region Planning Board

Consultant:
Wilbur Smith Associates

Drawn: SK | Checked: NSS
Date: April. 2010 | Approved: NSS

Scale: 0 25 50 75 100 Meters

Map 7-4



DETAILS OF SEWER LINES

Manhole No.		Length	Dia.	Slope	MH Top Level	Invert Level	Depth	MH Top Level	Invert Level	Depth
From	To	(m)	(mm)	1 in	(m)	(m)	(m)	(m)	(m)	(m)
1	2	196	250	196	101.30	99.30	2.00	101.26	98.27	2.99
2	4	420	300	500	101.20	98.22	2.98	101.18	97.36	3.86
3	4	196	250	196	101.28	99.28	2.00	101.18	98.28	2.96
4	6	36	450	600	101.18	97.23	3.95	101.18	97.17	4.01
5	6	196	250	196	101.28	99.28	2.00	101.18	98.28	2.96
6	8	490	450	750	101.18	97.17	4.01	101.00	96.52	4.48
7	8	196	250	196	101.10	99.10	2.00	101.00	98.10	2.96
8	10	30	450	750	101.00	96.52	4.48	101.00	96.48	4.52
9	10	196	250	196	101.10	99.10	2.00	101.00	98.10	2.96
10	12	490	500	1000	101.00	96.43	4.57	101.28	95.94	5.34
11	12	196	250	196	101.38	99.38	2.00	101.28	98.38	2.90
12	14	30	500	1000	101.28	95.94	5.34	101.28	95.91	5.37
13	14	490	250	250	101.00	99.00	2.00	101.28	97.04	4.24
14	27	270	600	1200	101.28	95.81	5.47	101.18	95.58	5.60
15	16	270	250	250	101.20	99.20	2.00	101.16	98.12	2.98
16	19	420	300	450	101.10	98.07	3.03	101.08	97.14	3.94
17	18	420	250	250	101.20	99.20	2.00	101.18	97.52	3.66
18	19	270	300	450	101.18	97.47	3.71	101.08	96.87	4.21
19	21	36	450	600	101.08	96.72	4.36	101.08	96.66	4.42
20	21	270	250	250	101.18	99.18	2.00	101.08	98.10	2.98
21	24	490	450	900	101.08	96.66	4.42	100.96	96.12	4.78
22	23	490	250	250	101.18	99.18	2.00	101.06	97.22	3.78
23	24	270	300	450	101.00	97.17	3.83	100.96	96.57	4.33
24	26	30	450	900	100.96	96.12	4.78	100.96	96.08	4.82
25	26	270	250	250	101.00	99.00	2.00	100.96	97.92	2.98
26	27	490	500	1000	100.60	96.03	4.87	101.18	95.54	5.64

DETAILS OF SEWER LINES

Manhole No.		Length	Dia.	Slope	MH Top Level	Invert Level	Depth	MH Top Level	Invert Level	Depth
From	To	(m)	(mm)	1 in	(m)	(m)	(m)	(m)	(m)	(m)
27	29	30	700	1000	101.18	95.34	5.84	101.18	95.31	5.87
28	29	490	250	250	100.90	98.90	2.00	101.18	96.94	4.24
29	42	270	700	900	101.18	95.31	5.87	100.18	95.01	5.17
30	31	270	250	250	101.10	99.10	2.00	101.00	98.02	2.98
31	34	420	300	500	101.00	97.97	3.03	100.96	97.13	3.85
32	33	420	250	250	101.10	99.10	2.00	101.08	97.42	3.66
33	34	270	300	450	101.08	97.37	3.71	100.96	96.77	4.21
34	36	36	450	750	100.96	96.62	4.36	100.96	96.57	4.41
35	36	270	250	250	101.08	99.08	2.00	100.96	96.00	2.96
36	39	505	450	900	100.96	96.57	4.41	100.80	96.01	4.79
37	38	490	250	250	101.08	99.08	2.00	100.90	97.12	3.78
38	39	270	300	500	100.90	97.07	3.83	100.80	96.53	4.27
39	41	30	500	900	100.80	95.96	4.84	100.80	95.93	4.87
40	41	270	250	250	100.90	98.90	2.00	100.80	97.82	2.98
41	42	475	600	900	100.80	95.93	4.87	100.18	95.30	4.68
42	46	36	800	600	100.18	94.91	5.27	100.18	94.85	5.33
43	44	195	250	220	101.38	99.38	2.00	101.28	98.49	2.79
44	45	330	400	500	101.28	98.34	2.94	101.18	97.68	3.50
45	46	270	400	500	101.18	97.68	3.50	100.18	97.14	3.04
46	47	453	800	600	100.18	94.85	5.33	97.80	94.10	3.70

Capcity Development of the NCRPB: Component B (ADB TA-7055)

Hapur
Proposed Sewerage System in Anand Vihar

Legend

1. M.H. — MANHOLE
2. SEWER LINE
3. 101.60 — MANHOLE TOP LEVEL
4. 100.50 — FORMATION LEVEL (BOTTOM OF GSB ADJACENT TO MEDIAN)

NOTES :

1. THE SIZE OF MANHOLE SHALL BE AS UNDER (INNER SIZES)
   a) 900 TO 1650 M.M. DEPTH — 900 M.M. DIA.
   b) 1650 TO 2250 M.M. DEPTH — 1200 M.M. DIA.
   c) ABOVE 2250 M.M. DEPTH — 1500 M.M. DIA.
2. M. S. RINGS SHALL BE PROVIDED IN EACH MANHOLE WHICH IS DEEPER THAN 800 M.M.
3. THE LEVELS OF SEWER LINES HAS BEEN WORKED OUT ON THE BASIS OF CERTAIN GROUND LEVEL AND FOR CERTAIN PIPE LENGTHS BETWEEN TWO MANHOLES. THE INVERT LEVELS HAS TO BE STRICTLY FOLLOWED. HOWEVER, THE SLOPE OF LINE MAY BE SLIGHTLY CHANGED.
4. FOR ANY DESCRIPENCY / OMMISSION THE MATTER SHOULD REFER TO THE CONSULTANTS BEFORE EXECUTION.
5. MANHOLE SHALL BE PROVIDED AT FOLLOWING PLACES :-
   a) AT THE START OF EACH SEWER LINE.
   b) AT EVERY JUCTION AND POSITION WHERE THERE IS CHANG" OF SIZE, GRADIENT AND ALIGNMENT.
   c) AT NOT MORE THAN 45 METER INTERVAL IN STRAIGHT LENGTH.
6. WHERE THE DIAMETER OF PIPE IS INCREASED THE CROWN OF THE PIPE SHALL BE FIXED AT THE SAME LEVEL AND NECESSARY SLOPE SHALL BE GIVEN IN THE INVERT OF THE MANHOLE CHAMBER.
7. THE STRUCTURAL DESIGN OF MANHOLES / PIPE BEDDING HAS TO BE DONE FOR LOCAL FIELD CONDITIONS SUCH AS FILLED UP SOIL / BLACK COTTON SOIL / HIGH SUBSOIL CONDITIONS.
8. SEWER LINE UNDER THE ROAD SHALL BE ENCASED WITH 150 THK PCC 1:2:4 ALL ROUND.
9. MANHOLE COVER SHOULD BE FINISHED WITH FINISHED FORMATION LEVEL AS PER LANDSCAPE DRAWING.
10. MATERIAL OF PIPE :-
    FOR 250 Ø AND 300 Ø — RCC (NP 2) PIPE
    FOR 450 Ø AND ABOVE — RCC (NP 3) PIPE

Client:
Asian Development Bank
National Capital Region Planning Board

Consultant:
Wilbur Smith Associates

Drawn: SK	Checked: NSS
Date: April, 2010	Approved: NSS
Scale: NTS	

Map 7-5

B. Sewerage System Improvement

1. Rehabilitation of Existing Sewerage System

85. The discharge capacities of the main trunk sewers have been calculated to establish if they have sufficient capacity for the peak flow for the horizon year 2041. The sewerage system has been designed such that existing sewers shall be apportioned flow as per their carrying capacity by diverting additional flow to newly proposed sewers. The adequacy of existing outfall sewer has been examined with respect to the flow generated from the apportioned area and it is found ok. However De silting and repair/replacement of damaged sewers and manholes would be required for most of the length. The existing pumping station shall be used under new system with discharge capacity same as designed earlier. The pump head will now increase corresponding to take flow up to new STP south. The mechanical and electrical equipment and installation will require total change as it has survived more than its life. The new pumps 4 no. 40 KW will replace existing pumps of 30 KW. The existing rising main 600 mm dia shall be used and its length will be extended by 1300 m PSCC pipe up to STP south. Existing sump and pump house building shall be used after repairs.

2. Proposed New Sewerage System

86. It is proposed to provide sewerage system to cater needs of project area. As per preliminary design the outfall sewer for zone 1 will be of 1000 mm, zone 3 shall be 1100 mm and zone 4 outfall shall be of 700 mm. The designs will be modified and updated after engineering surveys during detailed engineering. Lateral sewers at 125 meter per hectare have been taken. On this basis length will be about 650 KM in whole project area. RCC NP3 and NP4 pipes diameter 150 mm and 200 mm shall be used. PVC pipe 110 mm and 160 mm shall be used for making connections from house to sewer. The length of PVC pipe shall be approximately 410 Km. Interceptors, trunk mains and outfall sewer shall be RCC NP4/NP3 pipes; diameter shall be 250 mm -1100 mm. The length of interceptor, trunk main and outfall sewers shall be taken10 percent of the laterals i.e. about 65 Km. Road reinstatement has been taken 40 percent of total length of sewers considering laying of sewers on right of way but outside bituminous road as far as possible.

3. Sewage Pumping Stations & Rising Main

87. At present, two new pumping stations have been proposed one each for STP south and STP east. Minimum numbers of pumping stations have been proposed to save energy cost and make sewerage system more on gravity for reliability and less maintenance. However need of any additional pumping station if any shall be reassessed after engineering surveys. Wet well and DI rising main has been proposed for both SPSs. Non clog Submersible pumping sets are proposed. The wet well storage shall be 3.75 minutes at peak flow. In SPS south five pumps of 40 KW each, (Pumps to be same size and equal to 4 nos. for peak flow with 1 no standby) and in SPS east 3 pumps of 20 KW each, (2 working & 1 no standby for peak flow) have been proposed. These pumps will meet the

flow of year 2026. Thereafter pumps of total 300 KW at SPS south and 155 KW at SPS east shall be provided to cater the flow for year 2041.

4. Sewage Treatment Plant

88. Sewage Treatment Plant: Waste stabilization ponds have been proposed at two places STP south and STP east. WSP is a natural treatment process and does not consume energy in treatment process. Maintenance cost of WSP is less due to less mechanical parts. In view of poor financial strength of municipal corporation Hapur and rugged ness and less requirement of maintenance, WSP process is proposed.

89. The area on west of Meerut –Bulandshahar Road is generally flat at contour of 213 m, but the lowest point is towards Tatarpur village where Kali river passes. The contour here is of 210 m. In the master plan 2005 two sites for STPs have been marked, one is near Tatarpur village and on east side of city and is near to Kali River. Other site shown in the master plan is towards south near Chatauli village. These sites are suitable from engineering aspects as situated towards depression, low levels. The zone 1, 2, 3, 5 and 8 will drain in STP south and zone 4,6, and 7 will drain in STP east.

90. The total capacity of STP required for year 2041 will be 67 MLD. The construction shall be modular. Initially 25 MLD capacity shall be provided for STP south and 5 MLD for STP east. Subsequently in second phase capacity of STP south shall be further increased by 24 MLD. In third phase 14MLD capacity shall be additionally provided for STP east. The land required shall be 1.25 hectare per MLD, i.e. 61 & 24 Hectares respectively for south and east STP's. The provision for land acquisition has been made for first phase.

5. Water Reuse

91. The effluents after treatment in the respective STPs can be used for irrigation with fecal coli forms within the desired limits. Phosphates and nitrates are present in the effluent which is advantageous for irrigation. Considering approximately 10 % as reduction in volume after treatment and irrigation at rate of 125 - 250 m3/ha during dry seasons, 120 hectare can be irrigated on completion of first phase, year 2011, 163 hectares in 2026 and finally 300 hectare in year 2041.

C. Institutional Set-up

92. At present Municipal Council Hapur is operating and maintaining sewerage system. The maintenance is under Juniour Engineer. Capital works are done by UP Jal Nigam. UP Jal Nigam is a competent organization. Municipal Corporation lacks managerial and technical capacity and shortage of financial resources to upgrade, operate and maintain the sewerage system. The municipal corporation needs to be strengthened to handle sewerage system professionally. The engineering department of corporation should be restructured such that at least Executive Engineer heads all engineering operations, supported by four Assistant Engineers, one assistant engineer will be in charge of sewerage operations who will be

supported by 4 junior engineers dealing exclusively with sewerage. Municipal Corporation should be in charge of capital works also. However if required by them capital works can be got done from any other agency but Municipal Corporation should have capacity to over view the works.

1. Low Cost Sanitation

93. Experience of community toilets has not been good due to poor maintenance and after some time community toilets remain unutilized. Therefore community toilets shall be constructed only if beneficiaries can maintain and pay for use. Connection to sewerage system shall be encouraged. In slums also connection to sewerage system should be encouraged. Construction of toilets in all houses should be ensured to have city open defecation free. Provision of Rs 200 lacs have been taken for low cost sanitation & equipment for maintenance. For sewer cleaning a high pressure water jetting machine will be required together with a suction tanker.

2. House Sewer Connections

94. It is proposed to lay 110 mm/140 mm uPVC pipe under the project to connect sewage from house door to sewer man hole. This will ensure fast connectivity and avoid damage to manhole by unskilled people during connection.

3. Sustainability

95. Operation and maintenance cost should be recovered fully from beneficiaries so that proper maintenance is possible and scheme becomes sustainable. The total estimated cost is Rs 20347 lacs on current prevalent rates. The price contingency during implementation has not been taken. However provision of Physical Contingencies at 10%, Environmental mitigation at 1%, Social Interventions at 1%, Institutional Development Interventions at 1% & for design and supervision at 5% has been taken.

4. Phasing of Investment

96. Priority of Investment shall be as given below:

(i) Rehabilitation of existing system for zone 4 and land acquisition for STPs and Pump houses
(ii) Interceptors, Trunk mains and outfall sewers for zone 1
(iii) Sewerage in zone 2 & 3, Sewage Pumping Station
(iv) Laterals in zone 1
(v) STP South
(vi) STP East
(vii) Sewerage in zone 5, 6, 7 and 8. Priority among these will be as per development plan priority of HPDA.

97. Proposed phasing of investment and proposed works in each phase shall be as given below in **Table 7-1**, and the same is depicted in **Map 7-6**.

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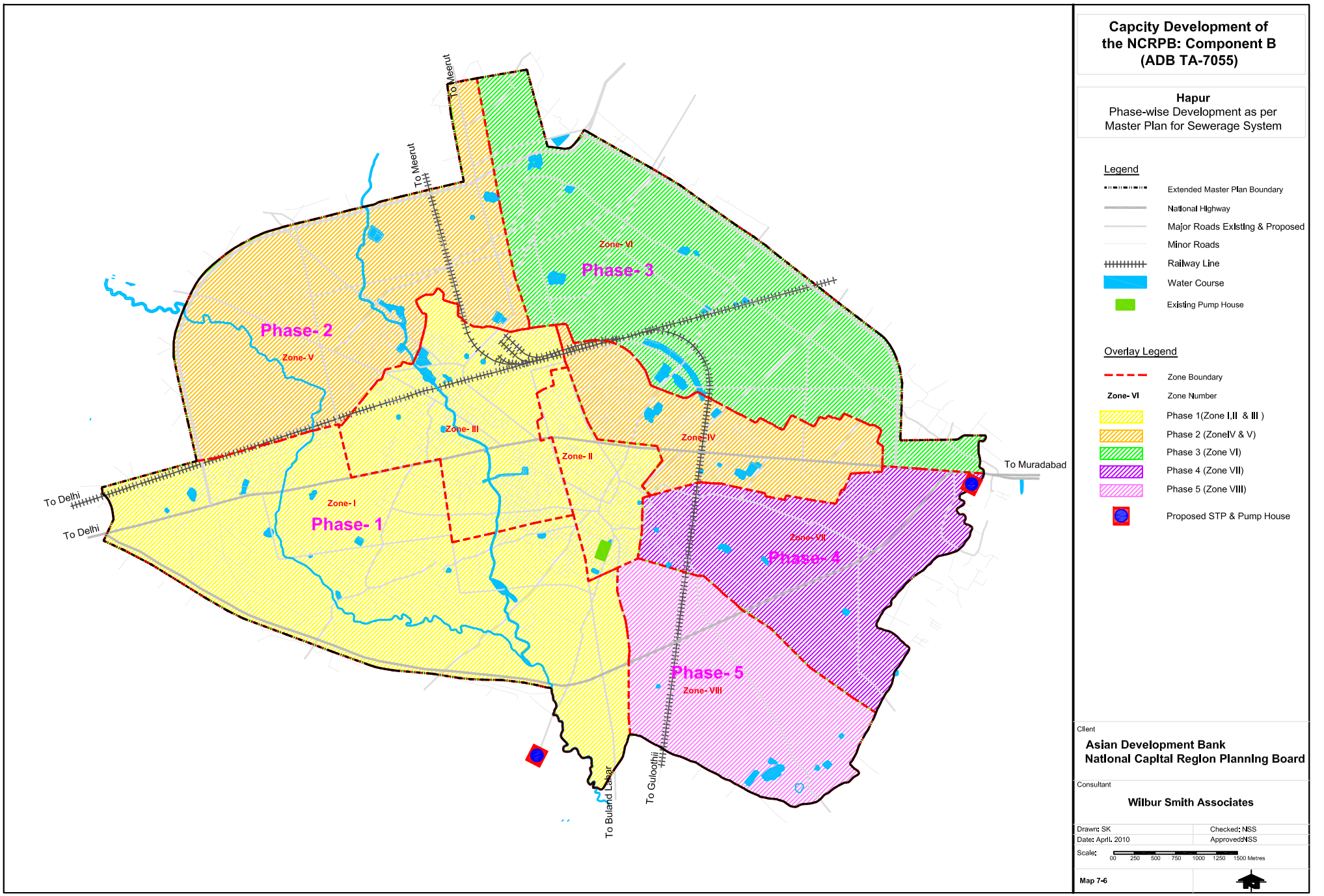
Table 7-1: Investment Phasing

Phase	**Phase 1**	**Phase 2**	**Phase 3**	**Phase 4**	**Phase 5**
	(2009-13)	(2014-18)	(2019-23)	(2024-28)	(2029-33)
2011	Rehabilitation of existing system and land acquisition for STPs and Pump houses, Sewerage in zone 1, 2 & 3, Sewage Pumping Stations and STP South and East	Sewerage in zone 5	Sewerage in zone 6	Sewerage in zone 7	Sewerage in zone 8

5. Operation & Maintenance Cost

98. Operation and maintenance cost after completion of first phase will be Rs.152.9 lacs which will increase by 56.69 lacs after 2nd phase, will further increase by 38.88 lacs after 3rd phase and will increase by 4 and 3.5 lacs after 4th and 5th phase. O & M cost after completion of all phase will be Rs. 256 lacs.



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Hapur
Phase-wise Development as per Master Plan for Sewerage System

Legend

- Extended Master Plan Boundary
- National Highway
- Major Roads Existing & Proposed
- Minor Roads
- Railway Line
- Water Course
- Existing Pump House

Overlay Legend

- Zone Boundary
- Zone- VI — Zone Number
- Phase 1(Zone I,II & III)
- Phase 2 (ZoneIV & V)
- Phase 3 (Zone VI)
- Phase 4 (Zone VII)
- Phase 5 (Zone VIII)
- Proposed STP & Pump House

Client
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates

Drawn: SK	Checked: NSS
Date: April. 2010	Approved:NSS

Scale: 00 250 500 750 1000 1250 1500 Metres

Map 7-6

8. DESIGN CRITERIA

A. Sewage Collection & Conveyance System

99. The sewerage system or water carriage system can be separate system or combined system or partially separate system depending on domestic sewage and rain water are drained through two separate set of pipes or through single set of piping. However, the combined system is not quite suitable in tropical Indian conditions as i) heavy and concentrated rainfall occurs during the monsoon period and thus there is a large variation in the quantity of sewage during different months of the year, ii) Dry weather flow is generally a very small proportion of the total flow and hence sewers are likely to get silted up due to low velocity of flow in lean periods, iii) capital funds are limited, iv) treatment costs and pumping costs are significantly reduced in separate system due to reduction in quantity.

100. The pipes for collection can have, i) Zonal pattern in which entire city is divided into suitable zones and a separate interceptor is provided for each zone, ii) Radial pattern in which sewers are laid radially outwards from the centre of the city to dispose sewage at multiple points, iii) interceptor pattern in which sewers are intercepted by large size sewers laid along the natural watercourses or iv) Fan pattern in which the STP is located at a certain point and the entire sewage flow is directed towards this point.

B. Estimation of Quantity of Sewage

101. Separate drainage system is proposed for rain water as such only dry weather flow will pass through sewers. The connection of roof, backyard and foundation drains to the sanitary sewers should be avoided and hence shall not be considered for estimation of sanitary sewage. The prevalent sewerage systems in India do receive rain water even if separate system for rain water exists but sewers are designed for 30 years and have spare capacity in early phases of implementation and considering that by end of 30 years sewerage system will become water tight to rain water, it is appropriate to design system assuming no rain water penetration in sewers.

102. The quantity of domestic sewage can be best estimated by quantity of water supply minus consumption and evaporation plus sewage flow from personal water sources which are other than those of community water supply and this water reaching to sewers. Another important factor in Indian cities is generally less connectivity of sewage to the sewerage system as many people continue to use on site sanitation i.e. septic tanks and soak pits etc particularly in colonies where sewerage system is laid after a long gap of construction of houses which is a general phenomenon in Indian cities. In actual practice about 70-80% of the water supplied is reaching to sewers. As such 80% of quantity of water supply can be taken as sewage generation.

103. *Infiltration and leakage*. Some quantity of ground water or subsoil water may infiltrate into sewers through defective joints, broken pipes etc. This is significant when water table is high and head of ground water is more than the head of sewage in sewers. Some quantity of sewage may leak out from defective joints and defective pipes when head of sewage is more in sewers than head of ground water outside. Infiltration and leakage mainly depends on quality of construction and water table levels. Infiltration can be considered 5000-50000 liters per day per hectare or 500-5000 liters per day per km length of sewers or 250-500 liters per day per manhole for sewers laid below ground water level.

104. *Estimation of Industrial Sewage*. The quantity of industrial sewage will vary with type and size of industry, the manufacturing processes involved, degree of water reuse and onsite treatment methods that are used, if any. However, in general the quantity of industrial sewage may be taken 80 to 90 % of quantity of water supplied through public water supply system. Some industries develop their own source of water supply and may discharge their liquid waste into sewers. This should be estimated separately for large industries. It may, however, be stated that industrial sewage should be treated to the standards prescribed by the Pollution Control Boards before being discharged into sewers.

C. Design Period

105. Sewerage projects are normally designed to meet the requirements over a period of 30 years after their completion. However, the period of 30 years may be modified in respect of certain components of the project depending on their useful life or the facility for carrying out extensions when required and rate of interest, so that expenditure far ahead of its utilization is avoided. As such design period for various main components has been taken as indicated in **Table 8-1**.

Table 8-1: Design Period of Sewerage Components

S. No	Design Component	Design Period	Remarks
1	Land Acquisition for STP, SPS, sewers etc	30 Years	Land acquisition in future difficult
2	Sewer network (laterals, Trunk mains, Outfall et)c	30 Years	Replacement difficult and costly
3	Pumping mains	30 Years	Cost may be economical
4	Pumping Stations-Civil Work	30 Years	
5	Pumping Machinery	15 Years	Life of pumping machinery is 15 years
6	Sewage Treatment Plants	30 Years	The construction shall be modular in phased manner as actual population less than design population and in Indian cities initially flows are much less due to connectivity problems.
7	Effluent disposal and utilization	30 Years	Provision of design capacities in the initial stages itself is economical

106. *Variation in rate of flow*. The rate of flow of sewage varies from season to season (seasonal or monthly variation), from day to day (daily variation) and from hour to hour (hourly variation). For design of sewers maximum or peak flow rates are adopted. The value of peak factor (ratio of maximum flow to average flow) depends on the contributing population and the values recommended in the Manual on Sewerage and Sewage Treatment prepared by CPHEEO are given in **Table 8-2**.

Table 8-2: Values of Peak Factor

S. No	Contributing Population	Peak Factor
1	Up to 20,000	3.00
2	20,000 – 50,000	2.50
3	50,000 – 75,000	2.25
4	Above 75,000	2.00

107. Peak factor can also be worked out by Babbit's formula, 5/P^0.2 or by Harmon's formula, 1+ (14/ (4+$P^{0.5}$)). Gifft formula for peak factor is 14/P^ (0.1667). P is contributing population in these formulas. The variation between maximum and average rates of flow is large for domestic and lateral sewers because they receive the flow directly from the source. This variation gradually diminishes as the flow reaches the branch or sub main sewers and the main sewers.

108. Minimum rate of flow: The minimum rate of flow may vary from 0.5 to 0.33 of the average flow.

D. Hydraulic Design of Sewers

109. The design for sewage collection system presumes flow to be steady and uniform. The unsteady and non uniform sewage flow characteristics are accounted in the design by proper sizing of manhole. The sewage is mostly liquid containing about 0.1% of solid matter and hence follows same laws of flow as water. However the difference in design for water supply network and sewer network is, i) In order to avoid clogging of sewers due to settlement of heavier particles of solids, sewers are to be laid at such gradient that self cleansing velocity is achieved at all values of discharge and that the inner surface of the sewers should be capable of resisting the wear and tear due to abrasive action of solid particles and ii) sewage flows under gravity as open channel flow and as such sewers are laid at continuous downward gradient.

110 *Depth of Flow*. The closed sewers should not run full, otherwise the pressure will rise above or fall below the atmospheric pressure and condition of open channel flow will cease to exist. Also from consideration of ventilation sewers should not be designed to run full. In case of circular sewers the velocity is maximum at 0.8 full and is 1.14 times the velocity at full flow. The discharge at 0.8 full is 0.98 times the discharge at full flow. Therefore the maximum flow depth should be 0.8 full at ultimate peak flow for all pipe diameters.

111. *Hydraulic Formulae for Design of Sewers*. The empirical formulas given by i) Chezy, ii) Ganguillet-Kutter, iii) Bazin, iv) Manning's and v) Hazen-Williams are prevalent. However Manning's formula has been used for design of sewers in case of gravity flow. For pressure flow (Pumping Mains), the Hazen-William's formula has been used. Sewer network design has been done with the help of Manning's Formulae i.e.

Velocity $V=[(1/n) \times (R^{2/3} .S^{1/2})]$ (in m/s)

For Circular Sections

$V = (1/n)(3.968 \times 10^{-3} D^{2/3} S^{1/2})$

$Q = (1/n)(3.118 \times 10^{-6} D^{8/3} S^{1/2})$

Where, Q = discharge in lps; S = slope of hydraulic gradient; D =internal dia of pipe line in mm; R = hydraulic radius in m; n = Manning's Coefficient of roughness

112. The Manning's Coefficient of Roughness (n) as per CPHEEO manual is given in **Appendix 5** and accordingly in case of spun concrete pipes (RCC and PSC) with socket and spigot has been taken 0.011 for new pipes and 0.015 for old pipes. For uPVC pipe the value of (n) has been taken as 0.011.

113. *Per Capita sewage flow*. The rate of water supply has been adopted as per the norms of CPHEEO manual as 135 LPCD at consumer end throughout the whole design period. 80 percent of the water supply has been considered as sewage flow into the sewerage system which works out 108 LPCD. In case of bulk consumers rate of water supply has been taken as per CPHEEO manual with a return factor of 80 percent or as per actual measured quantity of effluent.

114. *Minimum Velocity of Flow*. The velocity required to transport materials in sewers is only slightly dependent on conduit shape and depth of flow but mainly depends on the particle size and specific weight as given in **Appendix 6** and **Appendix 7**. The minimum velocity is more for lower diameters as stated in **Appendix 10**. A velocity of 0.6 mps would be required to transport sand particles of 0.09 mm size with a specific gravity of 2.65. Hence a minimum velocity of 0.6 mps for present peak flow and 0.8 mps at design peak flow is recommended for sanitary sewers. Thus the sewers are designed on the assumption that although silting might occur at minimum flow, it would be flushed out during peak flows.

115. *Recommended slopes for Minimum Velocity*. For sewers running partially full, for a given flow and slope, velocity is little influenced by pipe diameter. As such for present peak flows up to 30 lps, the slopes given in **Table 8-3** may be adopted which would ensure minimum velocity of 0.6 mps in the early years.

Table 8-3: Recommended Slopes for Minimum Velocity

S. No	Present Peak Flow in LPS	Slope per 1000
1	2	6.0
2	3	4.0
3	5	3.1
4	10	2.0
	15	1.3

S. No	Present Peak Flow in LPS	Slope per 1000
	20	1.2
	30	1.0

116. *Erosion and Maximum Velocity of Flow*. Erosion of sewers is caused by sand and other gritty material in the sewer and also by excessive velocity. Non-scouring or limiting velocities in sewers of different materials are given in **Appendix 8**. Accordingly maximum velocity for cement concrete pipes is 2.5- 3.00 mps.

117. *Sewer Transitions*. Sewers shall be designed to ensure that the energy gradient is a continuous smooth line, thus transitions from larger to smaller diameters shall not be made. The crowns of sewers shall be kept continuous. In no case, the hydraulic flow line in the large sewers shall be higher than the incoming sewer. To avoid backing up, the crown of outgoing sewer shall not be higher than the crown of incoming sewer.

118. *Minimum Size of Sewer*. Minimum pipe diameter recommended in CPHEEO manual is 150 mm except that in hilly areas, where extreme slopes are prevalent, 100 mm can be used.. Some states and ULBs have started adopting minimum diameter as 200 mm or even 250 mm. The logic is i) Maintenance of sewer system is generally not good and 150 mm dia sewer will block frequently and remain un attended for some time ii) Quality of construction in smaller size RCC main such as 150 mm is not good iii) The sewerage system is not totally closed one and undesired waste such as solid waste and drains finds way in sewerage, making smaller size sewer lines more prone to frequent blocking iv) The cost of pipe line element is only about 15 percent of total project cost and increase in pipe size from minimum of 150 mm to minimum of 200 mm size will increase cost of project by 2 percent whereas flow capacity increases by more than 80 percent. Hapur is comparatively smaller town and as such it is proposed to have minimum size of 150 mm but at junction of two pipes and further downward at least 200 mm pipe will be used. This way use of 150 mm has been kept minimum and only at start of sewer system.

119. *Material of Construction for Gravity Sewers*: Brickwork is used for large diameters as sewers can be constructed in any shape. However now it is not common. Concrete pipes are commonly used now as can be manufactured to any reasonable strength and laying is easy and jointing is leak proof. However these pipes are subject to corrosion where acid discharges are carried or where velocities are not sufficient to prevent septic conditions or where the soil is highly acidic or contains excessive sulphates. Only high alumina cement concrete should be used when it is exposed to corrosive sewage or industrial wastes. Salt glazed stoneware pipes are mostly manufactured in sizes 80-1000 mm but sizes greater than 380 mm are generally not used due to economic considerations. The length of these pipes is 60 cm, 75 cm and 90 cm. These pipes are good for corrosion resistance and erosion resistance. However due to less length, more joints, difficulty in jointing, requirement of special bedding and less compressive strength of pipes manufactured in India; use of these pipes is reducing in India.

120. AC pipes cannot stand high superimposed loads, subject to corrosion from acids in sewage and high sulphate soils, require special bedding and weak against erosion where high velocities are encountered; as such use of AC pipe is not prevalent. Cast iron, DI and steel

pipes are not used due to high cost. uPVC pipes are manufactured in sizes 75, 90,110, 140, 160,250,290 and 315 mm outer dia. uPVC pipes are smooth, light, easy to joint and have leak proof joint. Rates are also low. These days these pipes are used for making connection from house to sewer but not prevalent in street sewers. HDPE pipes available up to 630 mm dia are recent development in India but are costlier than RCC pipes and uPVC pipes. The welded joints are leak proof and as such some cities have started using these pipes.

121. GRP pipes are widely used in other countries where corrosion resistant pipes are required at reasonable rates. When using concrete or reinforced concrete, high density sulphur resistant cement should be used. These pipes are made of slag cement that contains fewer calcareous (CaOH2) particles than pipes made of Portland cement. These particles react with the sulphuric acid (created by bacterial dissipation of hydrogen sulphide) in sewers, causing the aforementioned crown corrosion. If this particular cement is not used, lifetime of concrete sewers cannot be expected more than 30 years. A comparative study of characteristics of various pipe options for gravity sewers is presented in **Appendix 11.**

122. The cost comparison of different types of pipes is done including cost of bedding and trench back fill material as these costs are substantial. On this basis RCC pipes are more cost effective and as such have been recommended. RCC NP2 pipes shall be used for depths up to 2-3 meter and below that RCC NP4 pipe shall be used due to lower cost. RCC Pipes shall be manufactured with sulphate resistant cement to minimize crown corrosion and increase life of pipe. In narrow and congested lanes without heavy traffic uPVC and HDPE pipes (6kg/sqcm pressure) are recommended.

123. *Minimum Cover*. The minimum cover without protection has been proposed 1.00 m above the pipe. With adequate cement concrete encasing the cover can be suitably reduced. The maximum depth of sewer pipe can be kept as per site conditions to minimize the number of pumping stations. Normally the same has been kept 8-10 m.

124. *Bedding.* Bedding shall be designed corresponding to laying condition of sewer in trench, embankment or tunnel as per CPHEEO manual. Generally sewers are laid in trenches by excavation in natural soil and then covered by refilling the trench to the original ground level. Four classes of beddings of A, B, C, and D are used for laying of sewers. Class A bedding may be either concrete cradle or concrete arch. Class B is bedding having a shaped bottom or compacted granular bedding with a carefully compacted backfill. Class C is an ordinary bedding having a shaped bottom or compacted granular bedding but with a lightly compacted backfill. Class D is one with flat bottom trench with no care being taken to secure compaction of backfill at the sides and immediately over the pipe and hence is not recommended. Class B or C bedding with compacted granular bedding is generally recommended. Shaped bottom is difficult and costly and hence not recommended. The pipe bedding material must be firm and not permit displacement of pipe.

125. The load on rigid conduit is calculated by Marston's formula, Wc=CdwBd2 where Bd is width of trench, w is unit weight of backfill and Cd is coefficient. Superimposed point loads and uniform loads, weight of pipe, effect of submergence are also considered. In case of flexible conduits (flexible joints such as socket and spigot joint with rubber ring) the load Wc will be less. The load carrying capacity is calculated as per three edge bearing strength of pipe multiplied with load factor. The load factors decrease for bedding from A to B to C to D.

126. The width of trench should be minimum possible to have less impact of external loads. The backfill material should be properly selected and compacted in layers achieving desired density so that external load impacts are reduced and future settlement and damages to surface roads are avoided.

E. Manholes

127. Manholes are proposed at every change of alignment, gradient or diameter, at head of all sewers and at every junction of sewers. The sewer shall be in a straight line between two manholes. The channels in manholes at junctions and bends shall be smooth with gradual transitions to avoid turbulence and deposition of solids. Manholes are usually constructed directly over the line of the sewer. They are circular, rectangular or square in shape. Manholes should be of such size that will allow necessary cleaning and inspection. The circular manholes have been proposed on all sewer lines. Poly elastomeric M S flats footrest has been provided for entry into manholes.

128. *Junctions.* A junction occurs where one or more branch sewers enter a main sewer. Apart from hydraulic considerations, well rounded junctions are required to prevent deposition. The angle of entry may be 30 degrees or 45 degrees with reference to axis of main sewer when branch sewer diameter is half or less than half the main sewer diameter. Junctions are sized such that the velocities in the merging streams are approximately equal at maximum flow.

129. *Spacing of Manholes*: For inspection, cleaning and testing of sewers, manholes shall be provided at every change of alignment, gradient, diameter, head of sewers and at junction of sewers. The spacing of manholes is given in **Table 8-4**.

Table 8-4: Size and Spacing of Manholes

Sewer size	**Manhole spacing**
Sewer < 900 mm	Maximum 30 m
900 –1,500mm	90 – 150 m
1,600 – 2,000 mm	150 – 200 m
> 2,000 mm	Up to 300 m

Source: CPHEEO Manual on Sewerage

130. *Size of Manholes*: Manholes should be sized to allow necessary cleaning and inspection. The sizes are given in table 14 Circular manholes are stronger than rectangular and arch type manholes and thus these are preferred over rectangular as well as arch type manholes. The width/ diameter of the manhole should not be less than internal diameter of the sewer + 150 mm benching on both sides. A slab, generally of plain cement concrete at least 150 mm thick shall be provided at base to support the walls of the manhole and to prevent entry of ground water. The thickness of the base shall be suitably increased up to 300 mm, for manholes on large diameter sewers with adequate reinforcement provided to withstand excessive up lift pressures.For inspection, cleaning and testing of sewers, manholes shall be provided at every change of alignment, gradient, diameter, head of sewers and at junction of sewers. Various types of manholes and details are provided in **Table 8-5**.

Table 8-5: Types of Manholes and Sizes

Rectangular		**Arch-type**		**Circular**	
Depth	**Size**	**Depth**	**Size**	**Depth**	**Size**
< 900	900 x 800				
900 – 2,500	1,200 x 900			900 – 1,650	900
		>2,500	1,400 x 900	1,650 – 2,300	1,200
				2,300 – 9,000	1,500
				9,000 – 14,000	1,800

Source: CPHEEO Manual on Sewerage
Note: All dimensions are in millimeter

131. *Covers and frames*. The size of manholes shall be such that there should be a clear opening of not less than 0.56m dia for entry. Steel Fibre Reinforced Concrete Covers (SFRC) conforming to IS 12592 (heavy duty HD-20 Grade designation) or cast iron manhole covers and frames conforming to IS 1726 (part 1 -7) has been proposed.

132. *Drop Manholes*. As per CPHEEO manual Drop manhole to be provided when a sewer connects with another sewer, where the difference in level between water lines (peak flow levels) of main line and the invert level of branch line is more than 600mm or a drop of more than 600mm is required to be given in the same line and it is uneconomical or impractical to arrange the connection within 600mm.

133. *Flushing*. In places where desired velocity (self cleaning) is not attainable in initial pipe sections, flushing by water tanker by a frequency of flushing at specified basis once in a day is to be considered. Flushing tanks are to be designed for 10 min. flow at a self cleansing velocity of 0.6 m/s.

134. *Inverted Siphon*. When a sewer line dips below the hydraulic grade line, it is called an inverted siphon. Design shall be done as per IS 411 Part III. It is necessary to have a self cleansing velocity of 1.0 mps for the minimum flow to avoid deposition. Multiple pipes at multiple levels with inlet and out let pipes and isolating valves should be provided ensuring ease of maintenance and minimum deposits.

F. Pumping Mains

135. Rising mains (pressure mains or force mains) are provided to carry sewage to higher elevations. It is generally provided to convey sewage from Sewage Pumping Stations to a higher level inlet chamber of nearby sewer or Sewage Treatment Plants. The size of the main should be determined considering initial cost and capitalized O & M cost for different sizes. It is designed according to the following considerations:

(i) A maximum velocity of 3.0 m/s at ultimate peak flow

(ii) Where flows are expected to substantially increase between 2026 and 2041 the option of laying a duplicate line at a later stage will be investigated, and

(iii) Each pumping station will be provided with an on line flow meter.

136. *Design Formula*. Hydraulic design has been done using Hazen-Williams formula which is given below:

$V = 4.567 \times 10^{-3} \ CD^{0.63} \ S^{0.54}$ and

$Q = 1.292 \times 10^{-5} \ CD^{2.63} \ S^{0.54}$

Where, Q - Discharge in m^3/hr; V - Velocity of flow in m/sec; d - diameter of pipe in mm;

C - Hazen-Williams Co-efficient; S - Slope of Hydraulic Gradient;

'C' Value adopted used in the hydraulic design has been taken 140 for DI pipes with cement mortar lining inside. 'C' values are given in the following **Table 8-6**. Alternatively modified Hazen-Williams formula can be used.

Table 8-6: Hazen-William Coefficients

S. No	Conduit Material	Recommended 'C' Values	
		New pipes	Design
1	Concrete (RCC & PSC) with socket & spigot joints	150	120
2	Asbestos cement	150	120
3	Plastic pipes	150	120
4	Cast iron	130	100
5	Steel welded joints	140	100
6	Steel, welded joints lined with cement or bituminous enamel	140	120

Source: CPHEEO Manual on Sewerage

137. *Duration of Pumping*. Considering the normal availability of electricity in the town 16 hours per day pumping has been considered.

138. *Minor losses for Fittings*. While calculating the head loss for flow of water through pipeline additional provision of 10 percent will be made over the theoretically calculated loss (using Hazen-Williams formula) to take account of the additional head losses for bends, tees, tapers, enlargers and valves etc. along the alignment of pumping main. However for short length rising main actual losses for different fittings should be calculated.

139. P*ipe Material for Risin*g *Main.* C.I. unlined pipes/PSC pipes have so far been used in pressure mains. The prevalent practice is to use ductile iron (D.I.) pipes with cement mortar lining/ zinc coated. Apart from superior metallurgical properties, D.I pipes with cement mortar lining / zinc coated possess numerous certain distinct advantages over CI unlined pipes. PSCC pipe are cheaper than other pipe materials but maintenance of PSC pipe especially replacement of pipe piece is very difficult, while replacement of pipe piece is very convenient in case of DI pipes. The life of DI pipe is also longer than PSC pipes and it may work out economical in the long run. A comparative study of different pipe options is given in **Appendix 12**.

140. In this case DI pipe has been proposed for rising main for pumping station at south STP and East STP as length is quite less, Pump houses are proposed near to the respective STPs. However in case of existing pump house it is proposed to use existing pipe and extend it further by PSC pipe up to STP south.

G. Sewage Pumping Stations

141. At places, where depth of sewer becomes too deep and it is difficult to lay sewer at such depths, sewage-pumping station has been proposed to lift the sewage to nearby manhole or to the STP, from where it will flow by gravity. Earlier the pumping stations used to be rectangular with dry and wet wells adjacent to each other or circular with central dry well and peripheral wet well or circular with a dividing wall to separate the dry and wet wells and with centrifugal pumping sets. Now wet well (no dry well) with submersible pumps are more prevalent. The construction is of RCC. Sulphate resistant cement is used in corrosive soils. Provision of flow measurement, adequate ventilation, safety equipments, pump lifting arrangements shall be made.

142. *Screens and Overflow*. All SPS will be provided with coarse screens before the wet well with clear opening of 40-50 mm between the bars for the manually cleaned type and 25 mm for the mechanical type. The screening units shall always be provided in duplicate. It is also proposed to provide bye bass on the upstream side, to avoid overflow of the screen channel in case of sudden power failure. Drainage facility shall also be provided in the individual screen channels to empty these channels for maintenance purposes.

143. *Wet Well*. The sewer line will discharge the sewage into a wet well. The capacity of sump should be such that deposition of solids is avoided and sewage does not turn septic. The capacity should not be too low to require frequent on-off of pumping sets. The capacity of the wet well is to be so kept that with any combination of inflow and pumping, the cycle of operation for each pump will not be less than 5 minutes and the maximum detention time in the wet well will not exceed 30 minutes of average flow. The high water level in sump well will not exceed invert level of lowest incoming pipe.

144. *Types of Sewage Pumps and Configuration*. Non clog submersible pumps are proposed in all Pumping stations as per availability in the Indian market. Pumping units are designed to handle suitably peak, average and low-flow from connected sewers. The capacity of pumps shall be adequate to meet the peak rate of flow with 50% standby. The general practice is to provide 3 pumps for a small capacity pumping station comprising 1 pump of

1 DWF, 1 of 2 DWF and third of 3 DWF capacity. For large capacity pumping station, 5 pumps are usually provided, comprising 2 of ½ DWF, 2 of 1 DWF and 1 of 3 DWF capacity, including standby.

H. Sewage Treatment Plants

145. *Types*. The removal of contaminants from sewage is brought by a sequential combination of various physical unit operations and chemical and biological unit processes. The physical unit operations include screening, grit removal and sedimentation. The biological processes is broadly classified as i) suspended growth processes, both aerobic and anaerobic, including activated sludge process, extended aeration, lagooning, nitrification, de-nitrification and anaerobic digestion and ii) attached growth processes such as aerobic and anaerobic filter processes. The treatment plants are also called primary treatment if treatment is limited to physical process, secondary treatment when treatment is up to biological treatment and tertiary treatment when treatment goes beyond biological treatment to meet some further requirement of effluent quality.

146. The treatment plants can be centralized or decentralized. In case of decentralized more number of smaller capacity plants are constructed. This system decreases cost of sewerage system but increases initial and O & M cost of STPs.

147. *Screening*. Screen is a device with openings generally of uniform size for removing bigger suspended or floating matter in sewage and are placed before SPS and STPs. Coarse screenings have opening of 75-100 mm for SPS and 50 mm for STPs. Medium screens have opening of 20-50 mm and fine screens have openings less than 20 mm. Coarse screens are manually cleaned but medium and fine screens are mechanically cleaned. Fine screens may be of the drum or disc or mat type. Quantity of screenings is about 0.0015 cum/ml with screen size of 10 cm and 0.015 cum/ml in case of 2.5 cm.

148. *Grit Removal*. Grit consists of coarse particles of sand, ash and clinkers, egg shells, bone chips and many inert materials of inorganic in nature. For STPs more than 10 MLD mechanical grit cleaning system should be provided. In case of manually cleaned grit chambers at least two units should be provided and all mechanically cleaned units should be provided with a manually cleaned unit to act as a bypass. The grit content is 0.05 to 0.15 cum/ml for domestic sewage. The minimum size of grit to be removed is 0.2 mm although 0.15 mm is preferred where ash content is more. Detention period of 60 seconds can be taken.The settling velocities and surface over flow rates for ideal grit chamber at 10 degree centigrade are given in **Table 8-7**.

Table 8-7: Settling velocities and Surface Overflow Rates for Ideal Grit Chambers

Diameter of particles	**Settling Velocity**		**Surface Overflow Rate**	
Mm	*mps*		*cum/d sq m*	
	Specific Gravity 2.65	Specific Gravity 1.20	Specific Gravity 2.65	Specific Gravity 1.2
0.20	0.025	0.0054	2,160	467
0.15	0.018	0.0039	1,555	337

Source: CPHEEO Manual on Sewerage

149. *Sedimentation*. For primary sedimentation tanks, both, surface overflow rate and detention period (Hydraulic Residence Time) are important design criteria as the solids to be settled are flocculent in nature and undergo flocculation. The major design parameters for secondary settling tanks designed to remove bio-flocculated solids are solid loading rate or solid flux as well as surface over flow rate. The overflow rates to be adopted are given in **Table 8-8**. The smaller values in the range are applicable for plants less than 5 MLD.

Table 8-8: Design Parameters for Settling Tanks

Type of Settling	**Overflow Rate cum/sq m. d**		**Solid loading Kg/sq m. d**		**Depth**	**Detention time**
	Average	**Peak**	**Average**	**Peak**	**m**	**hr**
A. Primary Settling						
Primary settling only	25-30	50-60			2.5-3.5	2-2.5
Primary settling followed by secondary treatment	35-50	80-120			2.5-3.5	2-2.5
Primary settling with activated sludge return	25-35	50-60			3.5-4.5	2-2.5
B. Secondary Settling						
Secondary Settling for trickling filter	15-25	40-50	70-120	190	2.5-3.5	1.5-2.0
Secondary Settling for activated sludge (excluding extended aeration)	15-35	40-50	70-140	210	3.5-4.5	1.5-2.0
Secondary Settling for extended aeration	8-15	25-35	25-120	170	3.5-4.5	1.5-2.0

150. The detention period of 2 to 2.5 hours for primary settling tank and 1.5 to 2 hours for secondary settling tank will produce optimum results. Longer detention period may affect the tank performance adversely due to setting in of septic conditions particularly in tropical climates. Longer detention period in secondary settling tanks may result in denitrification which adversely affects the settling efficiency. For all primary, intermediate and secondary settling tanks, except in the case of secondary tanks for activated sludge process, weir loading of the order of 125 cum/d.m. for average flows is recommended. For secondary settling tanks in activated sludge or its modifications, the weir loading is around 185 cum/d.m. The depth recommended for horizontal flow tanks are given in **Table 8-8** above and in vertical flow tanks, depth may be 2.0 m excluding hoppers.

151. Up flow tanks have been used for sewage sedimentation but horizontal flow types are more popular. Diameter of circular tanks vary widely from 3 to 60 m although common range is 12 to 30 m. Rectangular tanks, maximum length and widths of 90 and 30 m with length to width ratio of 1.5 to 7.5 and length to depth ratios of 5 to 25 are recommended.

152. *Secondary Sewage Treatment*. Many processes which are broadly classified as aerobic or anaerobic and as attached growth or suspended growth are prevalent for secondary treatment of sewage. The characteristics and salient features of these processes are given in **Appendix 9**.

153. *Design Period*. The STP may be constructed in phases with an initial design period of to 10 years excluding the construction period so that expenditure far ahead of utilization is avoided. In Indian city's sewer connectivity is generally at low pace as sewerage systems are generally developed many years after development of colonies and people already having septic tanks are not enthusiast to connect to sewerage system. Care should be taken to see that the plant is not considerably under loaded in the initial stages, particularly the sedimentation tanks. Comparative merits of 30 year design period or 15 year or even less period should be studied to find most economical option.

154. Selection of Sewage Treatment Plant Site:

- Suitable location for the discharge of treated effluent
- Sufficient area for future expansion preferably for 30 years period
- Should be away from residential areas to avoid odour problems, 200m buffer plantation zone recommended
- All weather access for the trucks to remove sludge/screenings/grit, etc.
- Minimum land resettlement issues - Government owned land is preferred to avoid land acquisition problems.

155. Criteria for Evaluating the Sewage Treatment Technologies

- Capital and O & M costs
- Land Area Requirements;
- Need for Mechanical and Sophisticated Equipment;
- Level of Supervision Required for Operation and Maintenance;
- Minimum energy consumption
- Need to meet effluent standards;
- Should be simple to construct and operate and have a low O & M cost
- Final use of the treated effluent.

156. Sewage Treatment Selection Criteria

- Capital and O & M costs
- Land Area Requirements;
- Need for Mechanical and Sophisticated Equipment;
- Level of Supervision Required for Operation and Maintenance;
- Minimum energy consumption
- Need to meet effluent standards;
- Should be simple to construct and operate and have a low O & M cost
- Final use of the treated effluent

157. *Influent Quality*. The design of STP will be based on measured values of sewage strength with an assessment made of the sewage dilution due to natural flows in the drains. The pH of fresh domestic sewage is slightly more than that of the water supply to community. However, the onset of septic conditions may lower the pH while the presence of industrial wastes may produce extreme fluctuations. Fresh domestic sewage has a slightly soapy and earthy odor and cloudy appearance. With passage of time, sewage becomes stale, darkening in color with a pronounced smell due to microbial activity. Nitrogen content is necessary for biological treatment and land irrigation and if inadequate it is necessary to supplement it. Chloride content in sewage will be 50 ml/liter more than that of water supplied (Contribution of chloride per person per day is 8 gm and water supply 150 lpcd). Any abnormal increase in chloride content indicates addition of chloride content waste or infiltration of ground water, the latter adding to the sulphates which may lead to excessive generation of hydrogen sulphide. Some heavy metals and compounds such as chromium, copper, cyanide etc which are toxic may find their way into municipal sewage through industrial discharges.

158. *Effluent Quality Standards*. The sewage after treatment may be disposed either into a water body such as lake, stream, river, estuary and ocean or onto land. It may also be utilized for industrial reuse or reclaimed sewage effluent in cooling systems, boiler feed, process water, reuse in agriculture and horticulture, watering of lawns, golf courses, ground water recharge or for preventing saline water intrusion in coastal areas. The effluent should fulfill statutory requirements laid down by pollution control boards for disposal in water bodies and for irrigation. The following **Table 8-9** shows the disposal standards for treated effluent according to the General Standards for Discharge of Environment Pollutants notified by Ministry of Environment & Forest (MoEF), GoI in May 1993.

Table 8-9: Effluent Disposal Standards

Parameters	**Standards for disposal in**	
	Inland Surface water	Land for irrigation
BOD (mg/l) 5days 20^0C	30	100
TSS (mg/l)	100	200
COD(mg/l)	250	-
pH	5.5-9.0	5.5-9.0

Parameters	Standards for disposal in	
	Inland Surface Water	Land for irrigation
Sulphides (mg/l as S)	2.0	-
Total Chromium (mg/l as Cr)	2.0	-
Faecal Coli form MPN/100 ml Desirable Maximum. Permissible	 1,000 10,000	

Source: CPCB

159. *Land Requirement*. Requirement of land as per different methods of treatment is given below:

Activated Sludge/Trickling Filter	-	0.5 acre/MLD
Aerated Lagoon	-	1.2 acre/MLD
Stabilisation Pond	-	2.5 acre/MLD
UASB	-	0.42 acre/MLD
Extended Aeration	-	0.35 acre/MLD

160. *On Site Sanitation*. Community/Public toilets will be provided for slum sanitation and sewage generated from the toilet blocks is either to be treated by constructing septic tanks followed by soak pits in the areas where sewer line is not available and sufficient space is available for its construction or to be disposed into the nearby sewer line and treated at the treatment plant. Size of the toilet block shall be decided depending upon the size of community and space availability. 10 and 20 seated toilet blocks will be provided. These units will be properly designed as per SP 35 (S&T): 1987 and CPHEEO Manual according to the number of users. However community toilets will be provided where beneficiaries are ready to maintain and bear cost of maintenance. The norms for use of such toilets are 50 persons per seat; therefore the number of users for 10 seat complex shall be 500.

9. DETAILED DESIGN

A. Engineering Surveys and Investigations

161. Information about topography, subsoil conditions such as types of strata, depth of ground water table and its fluctuations, underground structures like drains, water supply and sewerage lines, electric and telephone cables, gas line etc, existing and proposed land use, population density and trend of population growth, type and number of industries and commercial places, existing drainage and sewerage system, socio-economic data etc is required.

162. Planning for master plan was done based on available records such as Master Plan 2005, GT sheets of survey of India, map of existing sewerage system, proposed water supply map, land use 2007, sector maps of Anand Vihar and Preet Vihar of HPDA etc. The road map and levels of municipal area were available. However master plan 2005 area is more than 3 times the area of municipality and as such to plan for master plan area survey for whole area was required. As such for preparation of DPR topographical survey of all roads in the Master Plan area along with contour survey of proposed STP site areas was done. However to economize survey costs, total station survey was done for main roads, alignment of outfall sewer, intercepting sewers, drain and only levels were taken for other roads. The sector maps of HPDA, road map of municipal area and survey map developed under this project were integrated and used for design. Contour Map of Hapur Town developed through topographic survey is shown in **Map 9-1**. Base map prepared for design is shown in **Map 9-2**.

163. Fresh bore hole survey was not done as the underground strata is silt and fairly uniform. As such available strata details with HPDA/ Municipality were used.

164. *Review of Master Plan*. The master plan prepared earlier was reviewed in light of availability of fresh survey data particularly the area outside municipal boundary but within the master plan area. The project area was modified and limited to bypass road and the additional villages included in the project south of bypass were removed from project area as these villages are part of HPDA but not proposed under urbanisable area even in the proposed Master Plan 2021.

Capclty Development of the NCRPB: Component B (ADB TA-7055)

Hapur
Contour Map

Legend

- Master Plan Boundary
- Municipal Boundary
- Bypass Road
- Road
- Railway Line
- Drain

Overlay Legend

- Contour Line with Level

Client:
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates

Drawn:SK | Checked: HVS
Date: April 2010 | Approved: NSS

Scale: 0 300 600 900 1200 Meters

Map 9-1

Capclty Development of the NCRPB: Component B (ADB TA-7055)

Hapur
Base Map as per Survey

Legend

- Master Plan Boundary
- Municipal Boundary
- Bypass Road
- Road
- Rallway Llne
- Draln

Client:
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates

Drawn:SK	Checked: HVS
Date: August, 2009	Approved: NSS

Scale: 0 300 600 900 1200 Meters

Map 9-2

165. *Rehabilitation of existing sewerage network*. The existing sewerage network is 30 years old and almost nonfunctional. However some of the sewer lines can be used after clearing the blockages. This requires some serious effort of removing blockages from the existing network and then it will be known which of the lines can be used and which ones to be replaced. This requires time and financial and technical expertise. Municipal council responsible for maintenance does not have jetting machines and financial resources to take up the work. Under the circumstances, at present, sewer network has been designed keeping invert level and alignment of sewer pipes same as that of the existing network. In the mean time Municipal Council should take up sewer cleaning operation so that if blockage is removed from some line it can be used and the sewer lines which cannot be cleaned are replaced. The proposed design network allows it. Procurement of jetting machine has been proposed under this project also. Rehabilitation can be taken up under the project also. Thus, although the network has been designed to use and existing sewerage network wherever useable but simultaneously provision of total new network has been proposed to provide if rehabilitation is not successful or could not be taken up.

B. Design of Sewer Network

166. For the wastewater collection system design, in general, are based on the parameters and guidelines of CPHEEO's "Manual of Sewerage and Sewage Treatment" modified suitably for the project purpose, and or discretion depending on field conditions. The System Design Parameters proposed for the analysis of the existing sewerage system and the design of the proposed sewerage system is as follows

167. Design Period, area covered, population projection peak factor & waste water generation: The sewerage system has been designed for the peak flow for the year 2041. The population projection and densities are adopted as worked out in chapter VI. In this phase municipal area and adjoining habituated area has been considered which is draining in south STP. The municipal area which is draining in east STP has not been included in this DPR as STP land is to be finalized, The covered area is having 66% population.. Trunk main for proposed HPDA sectors 1 to 9 has been also taken. The Domestic water supply is considered as 135 LPCD at the consumer end up to the year 2041. Sewage generated is considered as 80% of the total water supplied. Based on this, the sewage generated works out to be 108 LPCD. Infiltration of ground water has not been considered as water table is below sewer level. Peak factor has been considered as per contributing population as given in CPHEEO manual and stated in earlier chapter.

168. The gravity sewage collection system is analysed and designed using Manning's formula. The general expression of the Manning's formula is:

$V = 1/n (R2/3) (S1/2)$

Where, V = Velocity in pipes in m/

S = Slope of Hydraulic Gradient

R = Hydraulic radius in meters

n = Manning's coefficient

Manning's roughness coefficient is considered as 0.013 for RCC/UPVC pipes.

5. *Minimum Depth of Cover and Minimum Size of Pipe*: To facilitate connection of house sewers to branch sewers and provide protection to sewers from external loads, the minimum depth of cover as far as possible for sewers is proposed to be 1 m. In case of non availability of adequate cover or laying of sewer in small lanes of old city where it is difficult to excavate for deeper trench to maintain standard cover of 1 m, lower cover shall be provided with fully encasement of pipes in cement concrete. Minimum size of sewer pipe shall be 150 mm as stated in CPHEEO manual. However here, two options were analyzed with minimum 150 mm and minimum of 200 mm. In view of flat topography of city and to reduce pumping the 150 mm pipes were changed in final design to 200 mm.

170. *Design criteria*: For hydraulic design of sewers, it has been ensured that depth of flow (d) does not exceed 0.8 times the pipe diameter (D) i.e. d/D 0.8 at ultimate peak flow in year 2041. Minimum gradient for sewers shall be designed to fulfill the requirement of self cleaning velocity, and to maintain minimum sewer cover and to avoid deep excavation. The crowns of sewers shall always be kept continuous.

171. *Pipe Material*: For house connections uPVC pipes of 60mm or 160mm diameter Class III (6.0 kg/cm2) are adopted. Jointing shall be done with Rubber Ring Joints. Two alternative designs were done, one using NP2 pipes and other adopting NP3 pipes. Suitable bedding was also designed for both options. In most of the length granular bedding is required. The overall cost of pipe and bedding is less in case of NP2 pipe and as such adopted. GSW pipe due to more joints is not proposed. The pipes shall be as per IS 458 and shall have ISI marking. The joint for the RCC pipes shall be Rubber Sealing Ring type.

172. *Self-Cleansing and Scouring Velocities*: To ensure that deposition of suspended solids does not take place, minimum self-cleansing velocities has been considered in the design of sewers. Minimum partial flow velocities of 0.6 mps at present peak flow and 0.8 mps at ultimate peak flows are suggested. In case of sewers in which the desired minimum (self cleaning) velocity may not be achieved at the beginning or later of commissioning due to low flows, it is recommended that suitable arrangements for cleaning and flushing of those sewers are implemented by the sewer maintaining line agencies. Maximum velocity (scouring velocity) has been restricted to 2.5 m/s.

173. *Bedding for Sewers*: The type of bedding (granular, concrete cradle, etc) shall depend on the width of trench, depth at which the sewer pipe is laid, the class of superimposed load considered based on the traffic condition and type of strata at the bed level. The type of bedding to be used for the particular type of pipes, depending on the specified depths shall be as per the methodology given in the Sewerage Manual. The bedding for the UPVC pipes shall be Granular Bedding up to 1.5m depth of pipe. For RCC NP2 pipes up to the appropriate granular bedding as per standard drawing of bedding shall be provided. Granular bedding is easy to lay and requires less time to execute the work in comparison to other types of beddings. Bedding has been designed for each length of pipe between two man holes. As per the design for NP2 pipe, in some reaches PCC and RCC bedding is required but in most of the reaches granular bedding is required.

174. *Manholes and Scrapper Man Holes*: Manholes have been proposed at all junctions and at all points of change of sewer size, gradient and direction. The design shall depend upon

the depth and the diameter of sewer. The maximum spacing between manholes is generally kept at 30 m centre to centre for sewers up to 900mm dia. The spacing between manholes for sewers 900 mm dia to 1500 mm dia shall be 90-150 m, for sewers 1600 mm dia to 2000 mm dia shall be 150-200 m. The clear opening at the top for ordinary manholes shall not be less than 560mm in diameter. Rectangular brick manholes for shallow depth sewers (up to 0.90 m) and circular manhole on sewer lines with depth greater than 0.9 m. shall be provided as per the standard drawings given in **Drg No. NCRPB/HAPUR/SW/SD-01 to 07**)[1] and conforming to IS 4111 (Part 1)-1986. Scrapper manhole / service manhole shall be provided at a spacing of 110-120. The internal diameter of manholes and scrapper man holes may be kept as following for varying depths:

Table 9-1: Types of Manholes and Description

Manhole Description	**Manhole Size**	**Type of Manhole**
For depth below 0.9 m and for outgoing pipe dia up to 300 mm	900 X 800mm	R-Type Manhole
For depth up to 1.65 m and for outgoing pipe dia up to 500 mm	900 mm dia	A-Type Manhole
For depth up to 2.30 m and for outgoing pipe dia up to 600 mm	1200 mm dia	B-Type Manhole
For depth up to 9.0 m and for outgoing pipe dia up to 900 mm	1500 mm dia	C-Type Manhole
For outgoing pipe dia of 1000 mm to 1400 mm	1800 mm dia	D-Type Manhole
For outgoing pipe dia of 1600 mm to 1800 mm	2400 mm dia	E-Type Manhole
Scarper Manhole (outgoing pipe dia of 450 mm to 900 mm)	1500 X1500 mm	G-Type Manhole
Scarper Manhole (outgoing pipe dia of 1000 mm to 1400 mm)	1800 X1500 mm	H-Type Manhole
Scarper Manhole (outgoing pipe dia of 1600 mm to 1800 mm)	2400 X1800 mm	I-Type Manhole

175. The manhole frame and cover shall be of heavy duty (HD-35) & (HD-20) Steel Fiber Reinforced Concrete (SFRC) capable of withstanding loads of 35 tonnes for main roads and 20 tonnes for side lanes, conforming to IS 12592 (Part I & II). The present local practice is to adopt brick masonry for construction of manholes due to local availability of bricks in abundance at cheaper rates and the same shall be followed.

176. *Drop Arrangement*: Drop arrangement is proposed for the laterals joining the manholes of main sewer where difference between invert levels of two sewers is greater than 600 mm. In the drop section, the pipes and specials shall be of uPVC of class III. Drop pipes to be encased with the PCC to support the pipe.

[1] All the detailed drawings are compiled in a separate Volume II-D: Detailed Drawings and appended to this Report.

177. *Vent Shaft*: To make provision for the escape of air to keep the sewage as fresh as possible in the sewers, it is proposed to provide vent shafts on the sewers of diameter of 300mm and above. Pre Cast RCC vent shaft of total 9.0 m height, projecting 7.50m above ground, shall be provided at the start of sewers and along sewers at critical junctions.

178. *Connections from Inspection Chambers to Manholes*: Sewer connections from inspection chamber to manhole are proposed in this scheme and the arrangement comprises of providing a facility to convey the wastewater from inspection chamber to sewer manholes. These inspection chambers will be constructed along the road side, as close to the house property lines as possible. The connection arrangement consists of providing and laying the uPVC pipes class III of 110/90 mm OD, from the roadside inspection chambers constructed near the property boundary, to the street manholes. It is proposed to construct one roadside inspection chamber for 2 or 3 house connections nearer to the manhole. In the existing houses, to promote connectivity provision has been made to connect waste from with in house to either directly to street man hole or through inspection chamber constructed outside home to the sewerage system. Alternatively this part can be left out as work to be done by beneficiaries in which case overall cost will reduce by Rs 66.23 million (6.62 crores). However as per past experience generally people do not connect as they already have septic tanks in place. Due to poor connectivity not only city remains unhygienic but flow in sewers is too less to generate self cleansing velocities and in case of STPs capacity remains unutilized. As such this work to lay pipe house to sewer manhole has been purposed to have 100% connectivity.

179. Based on road width, the property connection work can be divided into two categories A) With roadside chamber, B) Without roadside chamber.

(i) With roadside inspection chamber: In this case, for two properties, a roadside chamber shall be constructed close to the property boundary & 110mm Φ uPVC pipe class III shall be provided from road side inspection chamber to street Manhole. Openings are provided to Roadside inspection chambers so that the property owner can give the connection to the roadside chamber from his premise. The properties, which are close to the sewer line, will have a separate connection for each property to the manhole.

(ii) Without roadside chamber: The space may not be adequate to construct the roadside chamber if the road width is less than four meter. In this case, from each property, connection can be given directly to the manhole from both sides of the road through 110mm Φ uPVC pipe. As far as possible, the street sewer shall be laid at the centre of the road for road width less than four meters.

180. *House Connections.* Connections from individual house to the road side inspection chambers or directly to street manhole is also proposed under the package. The typical cases of house sewer connections likely to be encountered during construction are as follows.

(i) Case-1: Construction of Gully chamber for sullage inside property boundary.

Separate connection for WC and Gully chamber to road side inspection chamber constructed out side property boundary.

(ii) Case-2: Construction of Gully chamber for sullage inside property boundary. Separate connection for WC and Gully chamber to receiving chamber of clear opening of 400 X 400 mm constructed inside property boundary.

(iii) Case-3: More than one or two houses connected to road side inspection chamber with construction of Gully chamber for sullage inside property boundary. Separate connection for WC and Gully chamber to road side chamber constructed outside property boundary.

(iv) Case-4: House sewer connected to street manhole by providing uPVC pipe with gully trap for sullage discharge and without gully trap for WC discharge.

(v) Case-5: House sewer connected directly to street manhole without constructing Gully chamber, inspection chamber etc.

181. The process of connecting house sewer to street manhole or road side chamber is divided into two categories.

(i) House Sewer- Gully Trap to Street Manhole through inspection chamber: This type of arrangement shall be provided in those cases (case no.1, 2 &3) in which sewage and sullage are openly discharged outside property boundary through drain. A gully trap with gully chamber as per drawing are provided for sullage (discharge from kitchen, bathroom etc). Gully chamber is joined by uPVC pipe of 90mm OD to street manhole through inspection chamber constructed outside property boundary. A separate pipe of 110 mm OD for sewage (WC discharge) shall be laid and connected to manhole through inspection chamber.

(ii) House Sewer- Directly connected to Street Manhole: Properties having septic tank, inspection chamber, gully chamber etc in its premises will be directly connected to the main sewer at manhole. Properties have sewage as well as sullage outlet on road in isolated cases shall also be connected to street manhole through uPVC pipe without constructing inspection chamber. This type of arrangement shall be provided in case no 4 and 5.

182. The immediate need to provide an arrangement for house sewer connection is due to the following reasons:

- It was observed in the past that the general practice and tendency of public to connect house sewer to inspection chambers were not on priority basis as compared to taking water service connections. House sewer connections were taken by the local residents as per their own convenience. Therefore even in the areas where sewer networks are available, all sources of wastewater (including households) are not connected to the sewerage system. As a result, a significant volume of wastewater generated remains untapped and finds its way into the open areas, or drains which empty into the Lakes or flow somewhere else, contributing to the pollution load of the receiving water body and the areas. This unnecessary delay in house sewer connectivity to the inspection chambers will also affect the

functioning of respective sewers, pumping stations and the treatment plants.

- As per the current practice of making connection to the Man Hole, the masonry of Man Holes is damaged and the debris fall in manhole and it causes blockages in the sewers. Therefore it is good if houses are connected to Manholes at the time of construction of Man Hole.
- Laying pipe and connecting it to man hole at the time of construction of Manholes will also protect roads from future damages for connection to manhole.

183. House Sewer Connections to existing sewers: In case of house sewers which are to be connected to the existing sewers, connections are not recommended with Y or T connections as per the Sewerage Manual. It is recommended to be done by either of the following methods

- By directly connecting house sewer to the existing manhole when it is very near to the property line of the house.
- By making one roadside inspection chamber amongst 2 or 3 house connections nearer to the existing manhole and then connects it to the existing manhole.

C. Design of Trunk Main

184. Under sewerage Master Plan Hapur town has been divided into eight sewerage zones. The drainage pattern of the zones 1, 2, 3 and 5 (100% coverage) and part of 4 (4.44%) and 7(3.17%) are towards proposed STP at southern side of the town. The population covered from the above said zones in this sewerage scheme is 4,16,130 (Year 2041). This is about 66% of total population.

185. Trunk main alignment has been proposed by considering the topography of the town and major obstacles like National Highway and Railway track. Trunk main alignment has been fixed in such a way that it has to cross NH and Railway line at very minimal points. The proposed trunk main is passing the NH at one point and further downstream follows the alignment of existing nallah for a length of 7.23km finally leading to proposed STP at southern side of the town. The arrived diameter is about 300mm (min.) & max. diameter is of 1400mm. The total length of the sewerage system is about 140.52 km. The velocity has been maintained between 0.15 l/s to 0.93 l/s and d/D ratio is below 0.8.

186. The Master Plan area is draining in three STP's namely south STP, East STP and pockets (Valley) STP. The details of area, population and length of sewer in each zone is given in **Table 9-2**. STP wise coverage of area in different zones is given in **Table 9-3** and STP wise coverage of population is in different zones is given in **Table 9-4**. Details of pipe length of different dia are given in **Table 9-5**.

Table 9-2: Area, Population and length of network zone wise

Zone No.	Total Zone Area (m^2)	Total Zone population	Area Covered under South STP (m^2)	Population Covered under South STP	Network length (m) under south STP
Zone 1	1,283	115,835	454	40,943	11,397
Zone 2	183	83,730	179	81,780	44,100
Zone 3	497	152,547	480	147,337	55,177
Zone 4	364	58,925	19	3,050	4,192
Zone 5	910	60,060	860	57,729	14,761
Zone 6	1,091	71,940			
Zone 7	637	42,240	20	1,341	3,726
Zone 8	557	36,960			
Total	5,523	622,237	2,020	332,180	133,353

Note : i) Balance area and population (74892) of zone 1 is in HPDA sectors. Laterals will be provided by HPDA in this area as such not taken here. Trunk main 6781 m sewer line is proposed along the nalla to cater the flow from HPDA area. This length of 6781 m is not included in 11397 m network length. 387 m of network is going out side the city limits. Hence the total length of sewer pipes for south STP is 1333353+6781+387= 140521 m.

ii) Remaining Area and Population of zone 2 and 4 is under EAST STP.

iii) Remaining Area and Population of zone 3 and 5 is under pocket (valley) STP.

iv) Remaining area of zone 6 drains in East STP and some area not having roads not considered at present.

v) The remaining area of zone 7 is not considered as at present this remaining area do not have roads and habitation.

vi) Zone 8 is not having any roads and habitation at present and as such not considered.

Table 9-3: Area coverage under different STPs

Zone No.	Total Zone Area (Hectares)	Area covered under different STPs: hectares			Balance area: Hectares
		South STP	East STP	Pocket (Valley)	
Zone 1	1,283	454			830
Zone 2	183	179	4		
Zone 3	497	480		17	
Zone 4	364	19	346		
Zone 5	910	868		42	
Zone 6	1,091		682	40	370
Zone 7	637	20			616
Zone 8	557				557
Total	5,523	2,020	1032	99	2,373

Note: i) In zone 1 balance area is of HPDA sectors in which laterals will be laid by HPDA as such not provided in this scheme. However trunk main has been proposed for HPDA sectors.

ii) The balance area of zone6 ie 370 hectares is not considered at present, since there is no habitation or road network in this area.

iii) The balance area of zone 7 ie 616 hectares is not considered at present, since there is no habitation or road network in this area.

iv) The balance area of zone 8 ie 557 hectares is not considered at present, since there is no habitation or road network in this area.

Table 9-4: Population coverage in different STPs

Zone No.	Total Zone Population	Population covered under different STPs			Balance population
		South STP	East STP	Pocket STP	
Zone 1	115,835	40,943			74,892
Zone 2	83,730	81,780	1,950		
Zone 3	152,547	147,337		5,210	
Zone 4	58,925	3,050	55,875		
Zone 5	60,060	57,729		2,331	
Zone 6	71,940		44,962	2,610	24,368
Zone 7	42,240	1,341			40,899
Zone 8	36,960				36,960
Total	622,237	332,180	102,787	10,151	177,119

Note: i)Balance population of zone 1 ie 74892 is considered in the design of sewer network proposed in Nala for HPDA area.

ii) The balance population of zone 6, 24368 is not considered, since there is no habitation or road network at present.

iii) The balance population of zone 7, 40899 is not considered, since there is no habitation or road network at present.

iv) The balance population of zone 8, 36960 is not considered, since there is no habitation or road network coverage at present.

Table 9-5: Details of the length of the sewer network for different pipe diameters

S. No	Sewer Diameter (in mm)	Sewer Length (m)
1	200	111,862
2	250	3,969
3	300	2,637
4	350	3,739
5	400	3,905
6	450	1,598
7	500	1,631
8	600	6,041
9	700	485
10	800	706
11	900	794
12	1,000	-
13	1,100	1,645
14	1,200	-
15	1,400	1,506
	Total	**140518**

1. Trunk Main for Sectors Developed by HPDA

187. To connect the Existing sewer network in the HPDA area a separate sewer line is proposed. The depth of man hole in sector 2 (Preet vihar) is 3.55m and the contour level is of 212 m. The depth of manhole proposed HPDA sewer line near Nala is 4.83 m and the contour level is of 212 m. The length between the sector 2 MH and proposed HPDA Sewer line MH is 1000m. It is proposed to connect the sewer from sector 1 and 2 MH to the proposed HPDA Sewer line MH. Since the ground is flat, the sewer line from Preet Vihar MH to Proposed Sewer line can be laid at a flatter slope of 1 in 1000.

188. The MH of sector 5 near 132 KV sub-station can be connected to nearest proposed HPDA sewer line MH.

189. Additional sewer line is proposed for HPDA area along the Nala to connect existing sewer network of HPDA area to the proposed sewer line. Map xxx clearly shows the details of existing and proposed network.

190. *Equipment for Maintenance*: For sewer cleaning a high pressure water jetting machine will be required together with a suction tanker.

D. Design of Pumping Stations

191. Three sewage pumping stations have been proposed. Two of these will be located in the network. These are provided when depth of sewer reached limit of 8 m. One Sewage Pumping Station has been proposed at terminal point of STP South.. All efforts were adopted in deign to have minimum pumping to save energy cost and make sewerage system more on gravity for reliability and less maintenance. Wet well and DI rising main has been proposed for both SPSs. Non clog Submersible pumping sets are proposed. The salient features of the three pumping stations are given in **Table 9-**.

Table 9-6: Salient Features of Pumping Stations

Parameter	**SPS 1**	**SPS 2**
Sump Detention Time	20 Minutes	20 Minutes
Sump Capacity	37.4 cum	627.25 cum
Diameter of Sump	5.00 meters	19.5 meters
Liquid Depth of Sump	2.2 meters	2.2 meters
Pumping Head	15.5 meters	16 meters
Discharge of each Pump	40 LPS	590 LPS
Pumps Proposed	2 W+2 SB	2 W+2 SB
Each pump HP	17	255
Rising Main Pipe Diameter	250 mm DI K 7	1100 mm DI K7

SPS: Sewage Pumping Station

E. Design of Sewage Treatment Plant

192. *Capacity*: The treatment plant capacity as decided in sewerage master plan 25 MLD in south and 5 MLD in east in phase 1 is ok. This capacity was based on the basis that waste treatment capacity for planning year 2041 will be developed in phases on modular basis, i) to avoid heavy costs much before actual utilization, ii) slow pace of connectivity to sewerage network and long implementation periods. The capacity proposed will meet demand of year 2021 and additional capacities would be required to be created subsequently in phased manner as per pace of development of sewerage system and growth of city.

193. *Treatment Process*: As per the environmental pollution control act it is essential to treat sewage before disposal. The degree of treatment is also regulated under the Act which mainly depends on mode of disposal. However, to decide treatment process and mode of disposal is not easy. In the Sewerage Master Plan, Waste Stabilization Process was proposed due to i) Energy cost for operation of plant is very low ii) The biological treatment is natural and do not require mechanical parts and as such maintenance cost is very low iii) does not require skilled staff for operation iv) high percentage removal of pathogenic organism as compared to conventional plants v) simple operation vi) low initial cost vii) robust and sustainable system viii) suitable for tropical climate. Moreover, due to poor financial resources and technical capability of the Municipal Council Hapur and possible irrigation potential for reuse of the effluent, waste stabilization process appeared appropriate. The problem in WSP is that it requires much larger land than conventional plants (5 times more land than Activated Sludge Process plant). In case of Hapur the land is very costly as much as Rs 1crore (10 million) per hectare and as such the Master Plan recommendations for WSP were reviewed during DPR preparation.

194. In case of Hapur even after lot of deliberations the answer for suitable choice on treatment process is unclear. Finally two options are emerging for further deliberations. One option is to adopt WSP and locate STP South at about 500 meters south of bypass and along the drain and acquire 25 hectare land. The same land is used to house additional unit of STP and fulfill requirement of 30 years, but in that case the treatment process for all waste shall be mechanical conventional process where land requirement is about one fifth of that in Waste Stabilization Process. The second option is to construct 25 MLD extended aeration process. This can be located near drain just before bypass road as the land required will be only 3 hectares (7.25 acres). HPDA has proposed leather industries in this area.

195. Similar two options for East STP can be extended aeration process or waste stabilization pond. Land for STP is not yet decided and as such sewerage system and STP for East zone is not included in this DPR. Final decision between two options WSP or EA shall be taken after some more discussions with stakeholders and resettlement analysis.

196. Location: The Master plan 2005 has proposed site for south and east STP but the specific area has not been shown but indicated by a point (refer **Drg No. NCRPB/HAPUR/SW/STP-01)**. These sites are technically suitable. The Master Plan for the year 2021 is under preparation. This is proposing 3 sites of STPs, one in east adjoining Kali River, second in south just upstream of drain where it crosses bypass and third is in

west direction near Delhi-Lukhnau rail line and drain. These sites are also technically suitable. However the third site is not required at present as the area which will drain in it is not habituated at present.

197. Possible options for location of STP South are shown in **Drawing STP-02**. These options have been examined. The option 1, which is as per proposed Master Plan 2021, is most cost effective as length of outfall sewer will be less as compared to other options. It is on northern side of bypass and near the drain. However this land has been proposed by HPDA for leather industries and that the land is near the Bypass. Also WSP may not be possible here as the land required for WSP, 25 hectares is too high to get here. But, conventional plants such as extended aeration can be proposed here. The land required for extended aeration will be about 3 hectares (7.22 Acres), refer **Appendix D-4**[2]. Other options are about 500 m south side of Bypass. Site should be such that i) outside the corridor proposed in Master Plan 2021 for institutional development, ii) about 500 m away from Bypass, iii) upstream edge of site towards Hapur city should have higher ground level to allow fall of 3-4 meter towards downstream side to take care of head losses in plant, iv) general ground level should be above HFL of drain. On above basis option 3 (refer **Drawing STP-02** showing different options) appears more appropriate than others and as such proposed. Here the land is agricultural, it is about 250 meters from school and temple, it is in revenue boundary of Chatoli village, no permanent structures except some tube wells and pump houses, it is about 250-500 m from bypass. The options 2,4,5,6,7 are not as much suitable as option 3. If we go further downstream then it becomes near to school and temple. Size of land at option 3 is 573 m long and 415-420 m wide.

198 STP East can be located at the site given in the proposed Master Plan 2021. This is on edge of Kali River. The land required in case of WSP will be about 5 hectares and in case of extended aeration it will be one hectare, refer **Appendix D-5.** The problem seems to be low ground level and possible flooding in case of HFL in Kali River.

1. Design of STP: Waste Stabilization Pond

199. Design of STP south of 25 MLD on WSP process is given in **Appendix D-1**. Reference has been taken from Sewerage Manual of CPHEEO, Design Manual for WSP and Constructed Wet Lands prepared under DANIDA ENRECA grant, Design of Jodhpur STP, Bikaner STP etc. Fine screen and Grit channel has been taken 1 working and 1 stand by. Primary treatment consisting of coarse screen, fine screen and grit removal are designed for peak flow which has been taken 2.25 times average flow. Grit removal system designed to settle particles of 0.15 mm size and specific gravity above 2.3. Influent sewage BOD has been taken 300 mg/liter as per waste water sample tested, refer **Appendix D-6**.

200. Anaerobic pond and facultative pond designed for 13.89 ^{o}C which is mean minimum temperature in coldest month, refer **Appendix 1**, for temperature data. Depth of AP has

[2] All Appendices related to Design are compiled in a separate **Volume II-B: Detailed Designs**. All design related appendices are captioned as D-1, D-2…, where D indicates "Design". Similarly, all Estimate related appendixes are in **Volume III-C Detailed Estimates**; and are captioned as E-1, E-2....

been taken total 6 m which provides 1 m for sludge storage, 4 m for waste water and 1 m for free board. Detention time is 2 days. Surface loading has been taken as 177.8 kg/ha/day, 3 no APs size 108.8* 63.1 m provided. BOD removal in APs is 48%.

201. Depth of facultative pond has been proposed 3 m comprising 0.5 m for sludge, 1.5 m for biological treatment and 1 m for free board. Surface loading has been taken as 219.6 kg/ha/day and the detention time is 6 days. Two tanks of size 313.6&161.2 m at top has been proposed. Effluent BOD will be 75 mg/l and it meets requirement for its use for irrigation.

202. Helminth removal shall be 98.65 % and coli form removal 5.6%.

203. Effluent will be used for irrigation and for campus plants. Effluent sump shall be of 30 minute storage and of 13 m dia or 11.5*11.5 m rectangular. Depth of sump shall be 4 m effluent pumping shall be 2 working + 2 stand by pumps, each pump to deliver 150 LPS at 15 m head. Effluent shall also be used for scum cleaning. For this GI pipe 50 mm dia shall be laid from effluent pump house to a network of 50 mm GI pipe all around each FP and AP. Pumping shall be by one working and one standby pump, each pump capable to deliver 5 cum at 125 m head.

204. Brick pitching shall be provided along embankment slope towards water face and also at bottom of tank as the ground soil is pervious. Embankment face on other side shall be provided with grass turfing. Slope of embankment for AP and FP is 1:2.5. Top of embankment shall be 4.5 m wide and shall have road all around with street light posts at 30 m interval.

205. Administrative building 17.2 m by 7.5 m, watch man hut, control room, clear water tube well with pump and pump house, drain, approach road to ponds and office building with connection from existing public road, fencing all around the STP area, boat etc has been proposed. Plantation shall be done around AP and FP in an open area of about 8 hectares to arrest spread of bad smell which emanates from AP. Various elements of STP and details are shown in Drawings **Drg No. NCRPB/HAPUR/SW/STP-01 to 27**.

2. Alternative Design for STP South on Extended Aeration

206. Alternative design spread sheet for Extended Aeration based STP is given in **Appendix D-2.** Salient features about design parameters assumptions and details of proposed elements are given in **Table 9-7**.

Table 9-7: Salient Features &Design Parameters of 25 MLD STP South on Extended Aeration

STP Unit	Parameter	Value
	Influent BOD	300 mg/l
Inlet:	Detention Time	10 seconds
	Size	3.3 m*3.3m, 0.5 m depth of water + 0.3 m free board
Fine Screen	Size	3.6m*2.2m, 0.5 m depth of water + 0.3 m free board
Grit removal	Particle	0.15 mm

STP Unit	Parameter	Value
	Settling Velocity	0.02 m/sec
	Surface loading	974 cum/sqm/day
	Channel	23.1m*2.5m, 1.2 m SWD + 0.3 m free board, 2 No 1W+1 SB
	Removal Tank	Hopper 7.6 m *7.6 m, 1.5 m SWD + 0.3 m free board
Equalization tank	Detention Time	2.1 Hours
	Size & No.	31.5m*31.5m, 2.5 m SWD + 0.3 m free board, 2 No
	BOD Removal	15%
	Oxygen Reqd.	2 kg Oxygen per kg of BOD removal
Coarse Bubble	Aeration Grid	Capacity 13290 cum/hr
Aeration Tank	MLSS	2500
	F/M	0.12
		56.7m*56.6m, 4 m SWD + 0.5 m free board, 2 No
Blower	1 W+1 SB	Capacity 25835 cum/hr
	Membrane Diffuser	2584 No
	SVI	100
	HMCRT	19.77 days
	BOD Reduction	95 %
Secondary Clarifier	Surface loading	25 cum/sqm/day
	Size and No.	28.7 m Dia, 2.5 m SWD + 0.5 m free board, 2 No
	Detention Time	3.1 Hours
	BOD Reduction	20%
Return Activated sludge	Return flow capacity	50%
	Operating Hours	20
	Pumps	2 W+2 SB, each 86.81 LPS at 8 m head, 19 HP
sump	For treated sewage	8.1 m* 8.1 m, 4 m SWD + 0.3 m free board
Pressure sand filter	Loading rate	11 cum/hr/sqm
	Size	12.1 m Dia, shell height 1.8 m
	BOD Reduction	20%
Pumps	For filter feed	1200 cum/hr at 15 m head
Sludge	Disposal	20 No 16 m * 16 m, 1.8 m total depth
Disinfection	BPD Plant	3500 litres/hour
	Or Vacuum Chlorinator	1 W +1 SB, each 1 kg/hour capacity
Contact Tank	For Chlorination	Detention Time 15 Minutes
	Size	8.1 m* 8.1 m, 4 m SWD + 0.3 m free board
Area Reqd.		3 Hectares (7.22 Acres)
Location	Proposed	Near Chatauli Village

3. Design of 5 MLD East STP on Extended Aeration Process

207. Design spread sheet is given in **Appendix D-3**. Salient features about design parameters, assumptions and details of proposed elements are given in **Table 9-8**.

Table 9-8: Salient Features &Design Parameters of 5 MLD STP East on Extended Aeration

STP Unit	Parameter	Value
	Influent BOD	300 mg/l
Inlet:	Detention Time	10 seconds
	Size	1.7 m*1.7m, 0.5 m depth of water + 0.3 m free board
Fine Screen	Size	3.6m*0.5m, 0.5 m depth of water + 0.3 m free board
Grit removal	Particle	0.15 mm
	Settling Velocity	0.02 m/sec
	Surface loading	750 cum/sq m/day
	Channel	15m*1m, 1.5 m SWD + 0.3 m free board, 2 No 1W+1 SB
	Removal Tank	Hopper 4 m *4 m, 1.5 m SWD + 0.3 m free board
Equalization tank	Detention Time	2.1 Hours
	Size & No.	14.5m*14.5m, 2.5 m SWD + 0.3 m free board, 2 No
	BOD Removal	15%
	Oxygen Reqd.	2 kg Oxygen per kg of BOD removal
Coarse Bubble	Aeration Grid	Capacity 2660 cum/hr
Aeration Tank	MLSS	2500
	F/M	0.12
		25.8 m*25.8 m, 4 m SWD + 0.5 m free board, 2 No
Blower	1 W+1 SB	Capacity 5167 cum/hr
	Membrane Diffuser	517 No
	SVI	100
	HMCRT	19.77 days
	BOD Reduction	95 %
Secondary Clarifier	Surface loading	25 cum/sqm/day
	Size and No.	18.2 m Dia, 2.5 m SWD + 0.5 m free board, 2 No
	Detention Time	3.1 Hours
	BOD Reduction	20%
Return Activated sludge	Return flow capacity	50%
	Operating Hours	20
	Pumps	1 W+1 SB, each 34.72 LPS at 8 m head, 7.5 HP
sump	For treated sewage	4.2 m* 4.2 m, 3 m SWD + 0.3 m free board
Pressure sand filter	Loading rate	11 cum/hr/sqm
	Size	5.4 m Dia, shell height 1.8 m
	BOD Reduction	20%
Pumps	For filter feed	700 litres/hr at 15 m head
Sludge	Disposal	6 No 13 m * 13 m, 1.8 m total depth
Disinfection	BPD Plant	700 litres/hour
	Or Vacuum Chlorinator	1 W +1 SB, each 0.5 kg/hour capacity
Contact Tank	For Chlorination	Detention Time 15 Minutes
	Size	4.2 m* 4.2 m, 3 m SWD + 0.3 m free board
Area Reqd.		7250 sq m (1.8 Acres)
Location	Proposed	Near Kali Nadi

208. *Use of Effluent*: Effluent is proposed to be used for irrigation. A net work of pipe lines will be laid. It is not designed at present and Lump Sum provision has been taken. There is ample scope for use in agriculture as good fertile land is available nearby. The network

will be designed during implementation of scheme after identification and confirmation consent of prospective users. As stated in the Sewerage Master Plan, considering approximately 10 % as reduction in volume after treatment and irrigation at rate of 125 - 250 m3/ha during dry seasons, 120 hectare can be irrigated on completion of first phase year 2011.

F. Low Cost Sanitation

209. *Low Cost Sanitation and Equipment for Maintenance*: Experience of community toilets has not been good due to poor maintenance and after some time community toilets remain unutilized. Therefore community toilets shall be constructed only if beneficiaries agree to maintain and pay for use. Connection of houses to sewerage system shall be encouraged. In slums also connection to sewerage system shall be encouraged. Construction of toilets in all houses should be ensured to have city open defecation free. sewage generated from the toilet blocks is either to be treated by constructing septic tanks followed by soak pits in the areas where sewer line is not available and sufficient space is available for its construction or to be disposed into the nearby sewer line and treated at the treatment plant. Size of the toilet block shall be decided depending upon the size of community and space availability. 10 and 20 seated toilet blocks will be provided. These units will be properly designed as per SP 35 (S&T): 1987 and CPHEEO Manual according to the number of users. The norms for use of such toilets are 50 persons per seat; therefore the number of users for 10 seat complex shall be 500. Provision of Rs 200 lacs has been taken for low cost sanitation

10. COST ESTIMATES

A. Estimations

210. The estimate of various elements has been prepared by finding quantities of various items and then applying rates given in the schedule of rates (SOR). UP Jal Nigam SOR and UP Lok Nirman Vibhag SOR has been generally adopted. Delhi Schedule of Rates 2007 prepared by CPWD is more exhaustive and as such it has been used for items which could not be traced in UPJN and LNV SORs. The SOR 2006 prepared for MP urban Project has been adopted for other items. For remaining items market rate has been taken as rates were not available in above stated SORs. The SORs adopted are for different years; as such 5% per year has been added for price contingency for different items. As an example Delhi Schedule of Rates (DSR) is for year 2007 and as such 10% has been added on DSR items to make prices at current year 2009.

B. Contingency Adjustment

211. Provision for 3% for Design and Supervision Consultant (DSC) and third party inspection (TPI), 1% for Information Education and Communication (IEC) activities, 3% for Physical contingency, 1% for Environmental mitigation, 1% for Social intervention and 1% for Institutional development and capacity building has been taken so that other activities associated with the project are simultaneously taken up.

C. Basis for Estimation

212. *Estimate for bedding and Pipes*. The estimate per meter length for different types of beddings such as granular bedding (GRB), plain cement concrete bedding (PCCB), reinforced cement concrete bedding (RCCB), reinforced concrete encashment bedding (RCEB), reinforced concrete arch bedding (RCAB) and plain concrete encashment bedding (PCEB) has been worked out for different diameters and for RCC NP2 pipes, RCC NP3 pipes and RCC NP4 pipes and presented in **Appendix E-1 to E-6**. Rates of RCC NP2 pipe has been obtained from a supplier and rates of UPJN, rates of DSR and MP Urban project are tabulated in **Appendix E-10.** The rate of DSR has been adopted for pipes. For bedding quantity of cement concrete has been calculated in cum and UP JN rates applied for concrete. Pipe rate adopted and bedding rates per meter length for NP2 pipe, NP3 pipe and NP4 pipe are tabulated in **Appendix E-7, E-8 and E-9.**

213. *Estimate for Man Holes, Ventilating Shaft, Scrapper man holes and Inspection chambers*: Estimated cost for single unit of RCC ventilating shaft as per standard drawing enclosed at **SD-12** is given in **Appendix E-1.** Estimated cost for different types of Man Holes for different depths for one number is given at **Appendix E-2 to E-21.** The estimated cost for

single unit of different types of inspection chambers for connection of houses to Manholes is given at **Appendix E-22, E-23 and E-24**.The estimated cost for drop arrangement is given at **Appendix E-25**.The estimated cost of scrapper Man hole of type G is given at **Appendix E-26** and that for scrapper of type H is given at **Appendix E-27.** The consolidated unit cost of above items is given at **Appendix E-28.**

214. *Estimate for Sewer Network*. Quantities of earth work at different depths, quantity of refilling in trenches, quantity of road cutting, quantity of earth to be disposed off, quantity of bedding, no of man holes in different depth slabs, pipe length at different depths and diameter etc has been worked out in details for all pipes between different man holes. Due to large number of pages these are not attached in hard copy but enclosed as soft copy. The total quantities have been used in making the estimate. Some of the quantities such as for house connections, timbering, barricading etc has been calculated and shown in the enclosed sheets. The estimate for excavation for sewers, timbering and road reinstatement is given in **Appendix E-29**. The estimate for RCC pipes is given in **Appendix E-30**. The estimate for bedding is given in **Appendix E-31.** The estimate for man holes is given in **Appendix E-32**. The estimate for interconnection from road side chamber to man hole is given in **Appendix E-33**. The estimate for miscellaneous items such as barricading, vent shaft, demolishing, pedestals etc is given in **Appendix E-34**. The estimate for connection from house to sewer system is given in **Appendix E-35**. The estimate for rising main is given in **Appendix E-36**. The estimate for sewage pumping station is given in **Appendix E-37**.

215. *Estimate for 25 MLD Capacity STP South on WSP process*: The estimated cost of STP is Rs. 12.11 crore as per the abstract of cost given at **Appendix E-38**. The detailed estimate for different units and quantity calculations are given at **Appendix E-39** for anaerobic ponds and facultative pond earth work sand pitching, **Appendix E-40** for civil works for inlet, screens, grit units, distribution chamber, inlet/outlet units to anaerobic ponds and facultative ponds, **Appendix E-41** is for administrative building and watch man hut, **Appendix E-42** is for drains, **Appendix E-43** is for roads, **Appendix E-44** is for clear water tank, pump house and tube well, **Appendix E-45** is for miscellaneous items , **Appendix E-46** is for mechanical items and **Appendix E-47** is for electrical items.

216. *Alternative option of 25 MLD Extended Aeration STP*: The estimated cost for alternative option of extended aeration can be taken on per MLD basis as it will be constructed on turn kee basis and not as an item rate contract. Therefore in case of 25 MLD plant on extended aeration the per MLD cost as per prevalent market rate can be taken as Rs 1 crore per MLD. Therefore the estimated cost for 25 MLD plant is Rs 25 crore. The overall initial cost inclusive of Land in case of two options is given in the following

Table 10-1. Although initial cost is less for extended aeration but O & M cost is far less in case of WSP plant as compared to Extended Aeration.At present WSP has been considered but depending on availability of land and Resettlement issues final decision is to be taken in this respect.

Table 10-1: Comparative Cost of STPs

Cost	25 MLD WSP	25 MLD Extended Aeration
Initial cost	Rs 12.11 Crores	Rs 25 crores
Land cost	Rs 32 Crore for 32 Hectare	Rs 5 Crores for 5 hectares
Total	Rs 44.11 Crores	Rs 30 Crore

217. *Low cost Sanitation & Equipment for maintenance*: Provision of Rs 200 lacs have been taken for low cost sanitation & equipment for maintenance. For sewer cleaning a high pressure water jetting machine will be required together with a suction tanker.

D. Capital Cost

218. The total estimated capital cost of the project is estimated as Rs. 1,161 million (Rs. 11,607 lakhs). Abstract cost estimate is presented in the following **Table 10-2**, while the detailed cost estimates and bill of quantities are given in **Volume II C: Detailed Cost Estimates** appended to this Report**.**

Table 10-2: Abstract Cost Estimate

S. No.	Details	Amount (Rs.)
1	Earthwork in Excavation , Shoring & Strutting, Dismantling, Disposal of Surplus Earth, Road Cutting and Road Reinstatement Works	204,998,727
2	Supply and Laying RCC NP 2 Pipe Line works	82,850,714
3	Bedding and Allied Works	59,283,133
4	Manholes and Ancillary Works	99,083,565
5	House Chamber to Manhole Connections and General works	68,224,610
6	Miscellaneous Works	4,532,655
7	Connection with in house premises to Man hole/house chamber	66,226,589
8	Rising Main for 2 Pumping stations	3,030,129
9	Sewage Pumping Stations Civil woks	3,569,677
10	Sewage Pumping Stations Mechanical woks	2,190,000
11	Sewage Pumping Stations Electrical woks	1,235,400
12	Sewage Treatment Plant South 25 MLD on WSP Process	121,147,746
13	Land acquisition 32 Hectares	320,000,000
	Total	**1,036,372,945**
14	Contingencies	
i	Provision for Design and Supervision Consultancy and Third Party inspection of material @ 3%	31,091,188
ii	Provision for Information Education Communication Activity @ 1%	10,363,729
iii	Provision for Physical Contingency @ 3%	31,091,188
iv	Provision for Environmental Mitigation @ 1%	10,363,729
v	Provision for Social Intervention @ 1%	10,363,729
vi	Provision for Institutional Development @ 1%	10,363,729
vii	Incremental Administration(Implementing Agency expenditure) @ 2%	20,727,459
	Total Contingencies	124,364,753

	Total Project Cost including Contingency	**1,160,737,698**

E. Operation & Maintenance Cost

219. Operation and maintenance cost has been worked out as, sewers at 0.25% of capital cost, Mechanical and electrical equipment at 3% of capital cost, civil works at 1.5 % of capital costs, STP for WSP at 0.5 % of capital cost, energy cost for WSP and SPS has been worked out at actual as per flow in different years,, staff cost at Rs 25000 per MLD for STP and Rs 3.5 lac per SPS has been taken. Energy cost for pumping has been taken considering pumping of average flow for 24 hours a day and energy cost at Rs 4 per KW. The O & M cost will be Rs 13608644 per annum in year 2011 and will increase to Rs15401745 in year 2041 as given the following **Table 10-3**.-

Table 10-3: Operation and Maintenance Cost

Item	Capital Cost	O&M as % of Capital Cost	O&M Cost in year 2011	O&M Cost in year 2021	O&M Cost in year 2031	O&M Cost in year 2041
Road Reinstatement Works	100,257,021	1.50%	1,503,855	1,503,855	1,503,855	1,503,855
Supply and Laying RCC NP 2 Pipe Line works	82,850,714	0.25%	207,127	207,127	207,127	207,127
Bedding and Allied Works	59,283,133	1.50%	889,247	889,247	889,247	889,247
Manholes and Ancillary Works	99,083,565	1.50%	1,486,253	1,486,253	1,486,253	1,486,253
House Chamber to Manhole Connections and General works	68,224,610	0.25%	170,562	170,562	170,562	170,562
Miscellaneous Works	4,532,655	1.50%	67,990	67,990	67,990	67,990
Connection with in house premises to Manhole/house chamber	66,226,589	0.25%	165,566	165,566	165,566	165,566
Rising Main for 2 Pumping stations	3,030,129	0.25%	7,575	7,575	7,575	7,575
Sewage Pumping Stations Civil woks	356,977	1.50%	5,355	5,355	5,355	5,355
Sewage Pumping Stations Mechanical woks	2,190,000	3%	65,700	65,700	65,700	65,700
Sewage Pumping Stations Electrical woks	1,235,400	3%	37,062	37,062	37,062	37,062
Sewage Treatment Plant South 25 MLD on WSP Process	121,147,746	0.50%	605,739	605,739	605,739	605,739
STP Energy Cost, 9.5 KWH per MLD , 16 hour working,			275,874	346,750	346,750	346,750
SPS 1 Energy cost			171,307	225,813	295,893	389,333
SPS 2 South STP Energy cost			2,055,680	2,709,760	2,709,760	2,709,760
Energy Cost for Irrigation pumps, 2w+2 SB, 150 LPS at 15 m head, KW is 36.76 each pump			1,366,385	1,717,427	1,717,427	1,717,427
Staff Network			2,000,000	2,000,000	2,000,000	2,000,000
Staff SPS 3.5 lac per Pump house			1,050,000	1,050,000	1,050,000	1,050,000
Chemicals STP: Rs 30000 per MLD			497,250	625,000	625,000	625,000
Staff STP: Rs 25000 per MLD			596,700	750,000	750,000	750,000
Total			**14,418,221**	**15,862,479**	**15,974,607**	**16,124,111**

11. INSTITUTIONAL ISSUES

A. Organizations Involved

220 *Directorate of Local Bodies.* It develops acts, policies, guidelines etc. to strengthen local administration through empowerment of local bodies like Nagar Nigams, Nagar Palika Parishads and Nagar Panchayats. It not only formulates policies for urban development but also is a regulatory body with control over various ULBs including Hapur Nagar Palica. Although, ULBs are authorized to levy cess/taxes and formulate bye laws in relation to sewerage, the Directorate of Local Bodies, GoUP, helps them to formulate such laws and tries to bring in some homogeneity amongst various ULBs.

222 *Uttar Pradesh Jal Nigam*: It operates as an autonomous organization under DUD, GoUP. It was constituted under UP Water Supply and Sewerage Act, 1975. As per the Act, it is responsible for planning and development of water supply, pumping stations, sewage treatment plants and the discharge of effluents in rivers after treatment so as to improve river water quality. However, in line with the spirit of 73rd and 74th Constitutional Amendment Act (CAA), responsibility of 15 out of 18 functions defined in the CAA have been transferred to ULBs by way of amendments carried out in the Municipal Act of UP. As a result, UPJN is now responsible for planning and implementing sewerage infrastructure for Hapur, whereas O&M function of sewerage infrastructure lies with Hapur Nagar Palika.

223 *Department of Town and Country Planning (DTCP)*: This Department is responsible for developing prospective land use plans (Master Plan) of urban areas besides formulating state-wide policies on urban development and on development controls (like FAR etc.). The formulation of such plans takes into consideration the social, commercial, economic and ecological factors as well as the assessed growth potential due to other factors including agriculture, climate, availability of raw materials, existence of mines, etc.

224 *Uttar Pradesh Pollution Control Board (UPPCB)*: Working under the Department of Environment, the major function of the UP State Pollution Control Board is to formulate pollution standards (mostly in line with CPCB standards) for water, air, noise etc. and to advise the state government on any matter concerning the prevention, control or abatement of pollution. It is thus responsible for setting standards for drinking water quality, effluent standards, river/nala water quality standards as well as of nala water falling into the rivers besides monitoring and controlling the untreated effluents coming out of the industries. The standards set by UPPCB on quality of water to be discharged into rivers are very important for selection of technology and designing STPs etc. and therefore has indirect influence on the project.

225 *Department of Revenue*: Department of Revenue, Government of UP is the official custodian of the government lands including water bodies. All land records are maintained by this department. They are engaged in transfer of land rights, issue of pattas, leasing of land etc. The department has a role in the project, if land is to be acquired for construction of STPs, pumping stations and even laying of sewerage infrastructure etc.

226 *Urban Local Bodies*: As per amendments in the Municipal Act, 1916, in line with the 73rd and 74th Constitutional Amendment Act, all ULBs are mandated to provide their respective residents with 15 basic urban services (out of 18 as envisaged under CAA) like water supply, sanitation, street lighting etc.

227 *Development Authority*: Working with Department of Housing, GoUP, there are Development Authorities constituted for different cities and for some designated areas. They plan and develop plots of land in and around the local bodies, particularly for larger urban centres. In these land development projects, they develop roads, drainage and sewers, and even buildings for sale to the individuals and private sector. Hapur town falls under the jurisdiction of the Hapur Pilkhua Development Authority (HPDA).

228 *District Urban Development Agency (DUDA)*: The District Urban Development Agencies, at the State level, are controlled by the Department of Poverty Alleviation under the Ministry of Urban Development. These Agencies focus on slum development, roads, drains in colonies with weaker sections of society and SC/ST communities as well as with the rehabilitation and resettlement associated issues. The agencies work under the administrative control of District Magistrates. Generally, a designated project officer plans and implements such developmental activities.

B. Organizational Constraints and Concerns

229 UPJN has better technical expertise in planning; construction and management of sewerage infrastructure and ULBs still lack such capabilities. Therefore, in the spirit of CAAs, there is an increasing need to transfer required "expertise" from UPJN to ULBs, mainly focusing on operational management aspects of sewerage and drainage infrastructures. This could be achieved by transfer/deputation of personnel of UPJN to ULBs.

230 *Human Resources*: The HNP is mostly staffed with operation and management/ maintenance employees. Most of the staff is engaged in solid waste management and in sewerage management. Further due to ban on recruitment, the average age of staff is high, causing some restrictions on possible capacity building efforts as well as their efficacy.

231 *Human Resource Management Policies*: The Human Resource Management Policies are quite old and do not support competency building, performance linked promotions etc. In fact, annual performance reports are considered as formalities and no "positive" cognizance is taken of such reports in promotions/compensation. Further, there is neither a

system nor specific funds for training and capacity building of the staff. In brief, there is general lack of forward-looking HRM policies.

232 *IT and E-governance*: Use of information technology is still low in the ULB. There is no e-governance system operating in the Hapur Nagar Palika

233 *Management of Sewerage Infrastructure*: The responsibility of operation and maintenance of sewerage infrastructure now lies with the ULB. Overall the sewerage infrastructure maintenance needs lot of improvements. This state is mainly due to lack of availability of senior engineer and supporting staff in the HNP besides lack of funds for management. Overall, the O&M of sewerage infrastructure requires serious improvements both organizationally as well as financially.

234 *Charges of UPJN*: The fees charged by UPJN for planning and implementation of water supply and sewerage infrastructure is 13%, whereas they charge specific annual fees for O&M of various sewerage infrastructures. With the growth of private organizations providing similar services at much lower rates, competition in the sector is growing. With increasing transfer of powers to ULBs as well as increasing emphasis on PPP and privatization, it is anticipated that some of these services may be outsourced to private organizations.

235 *Lessons learnt from Experiences of HNP and other ULBs*: The experience of sewerage infrastructure development and management has not been very encouraging especially the operation of STPs. Under YAP I, several plants of UASB design were installed and most of them are under operation. However, their performance, whether run by UPJN or by contractors, raises several concerns. Similarly, the condition of trunks, mains and sewer lines raises several concerns. The reasons cited are numerous including poor operation and maintenance, poor construction, erratic power supply, problems of diesel for generators, lack of proper sewerage management policy, low sewerage tax/cess combined with poor financial health of ULBs, non-willingness of politicians to increase sewerage tax/cess etc.

C. Recommendations for Organizational Reforms

236 Exposure visits to better performing ULBs and well managed Sewage Treatment Facilities and to well managed River Systems to understand their project planning process, operation and management, management framework, water quality measurement, pollution control techniques, automation, data records and analysis techniques, computerization, feedback mechanism, MIS etc.

237 HNP must be reorganized to have a separate division on Water Supply and Wastewater Management, which should be headed by an engineer of the rank of at least Executive Engineer with adequate number of staff (minimum four assistant engineers and nine junior engineers). This division should be progressively managed in a business-oriented manner. To be effective, the division should work as a business entity and therefore must pursue low and affordable costs of operation and better tax recoveries for sewerage over a period of time. This would require transparent and equitable tariffs/taxes, exercising ruthless cost

controls and improved operational and financial management. The progressive business orientation, in its broader sense, would require meeting the O&M expenses in first few years (less than 5 years from project implementation), meeting O&M and replacement expenditures in 5-10 years and thereafter meeting total costs (operation, management, replacement, depreciation, interest on capital for new infrastructures etc.) so that the Water and Wastewater Division of HNP becomes self sustaining, at least in long run.

238 UPJN should pro-actively and systematically integrate the views/suggestions of ULB in planning of sewerage facilities. It is very important in the sense that choice of technology etc. has a direct impact on the O&M costs as well as component replacement costs. Therefore, choice of a specific technology with high O&M or replacement costs (as in membrane technology) could financially tax the ULBs in short term or in a long run, which could be beyond their capacities. The views and limitations of ULBs must be seriously considered besides life cycle cost analysis of various technological options.

239 To improve efficacy of operational management of sewerage infrastructure, automation and control in operation of pumps etc. need to be introduced on priority. This would substantially reduce human resource requirements as well as current operational expenditures.

240 Involve beneficiaries such as public, NGOs, CBOs in project formulation and implementation.

241 A long-term strategy to develop capacity of HNP needs to be agreed. The strategy would encompass institutionalization of competency building by provision of continuous training to ULB staff on sewerage and drainage related issues, guidance by UPJN for development of support resources within the ULB to increase the effectiveness of training and providing a pro-active role to UPJN in technology transfer to GNN using UPJN's existing/retired professionals as engineering expert, O&M manager, trainer etc. To support such an initiative, the possibility of deputing UPJN officials to GNN needs to be further explored.

242 To support the project's environmental development objectives and to ensure that the benefits of the project efforts reach a larger section of society, there is a need to integrate the needs of economically weaker and vulnerable sections of the society, especially women and children within these groups and those living in the slums.

243 Till tariffs are revised, state should provide subsidy/funds to meet the short fall.

244 Computerize ULB activities and provide equipment. Develop base maps and spatial information on land use, landform, surface hydrology, and settlement patterns. Collection and management of spatial data, information on sewerage management infrastructure including the type, age, cost, repair history etc.

245 Enhance operation and maintenance capacity and capabilities for sewerage and drainage facilities, Higher level of safeguards for health and safety, Ability to comprehensively assess the environmental, social, and economic improvements and Improved monitoring of effluent quality across the project area.

246 The energy for pumping and other operations is a major issue under erratic power supply situation in UP. The provision of generators has not resulted in proper pumping due to non-availability of operational funds for diesel and/or due to pilferage at operational levels. Therefore state level actions must be made to provide power on “priority” for wastewater management facilities operated by ULBs.

Appendices

Appendix 1

Appendix 1
Mean Temparature, Ghaziabad District

Table 1 Mean Minimum Temparature (Degrees Centigrade)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	6.68	10.16	14.11	20.82	26.96	29.67	27.04	24.12	24.05	19.75	12.86	8.48
1996	7.37	10.18	16.36	21.59	25.52	26.27	26.25	24.49	23.86	18.73	11.88	7.25
1997	6.25	9.43	14.72	19.56	23.56	25.66	27.1	25.22	24.19	16.89	11.83	5.91
1998	5.79	10.05	13.34	21.71	26.74	27.74	26.57	25.5	24.74	19.21	13.11	8.2
1999	6.67	10.91	16.73	23.66	26.29	27.16	27.42	26.68	24.56	19.45	13.71	8.58
2000	7.42	8.57	14.82	23.2	26.85	26.16	25.71	26.08	24.65	19.89	14.04	8.98
2001	6.55	10.6	15.48	21.22	25.32	25.5	26.71	26.83	25.54	20.34	13.8	9.16
2002	7.53	10.07	16.18	22.97	26.77	27.62	28.4	26.55	22.71	19.68	13.26	8.91
	6.78	10.00	15.22	21.84	26.00	26.97	26.90	25.68	24.29	19.24	13.06	8.18

Table 2 Mean Average Temparature (Degrees Centigrade)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	13.79	17.3	21.62	28.32	34	35.29	31.22	27.86	28.96	26.78	20.67	15.9
1996	14.48	17.39	23.66	29.14	32.46	31.92	30.44	28.11	28.61	25.76	19.68	14.8
1997	13.38	16.58	22.22	27.11	30.61	31.42	31.2	29.03	29.11	23.92	19.63	13.3
1998	12.89	17.26	20.85	29.24	33.73	33.36	30.68	29.23	29.4	26.25	21.11	15.8
1999	13.69	18.05	24.23	31.16	33.34	32.92	31.6	30.47	29.29	26.44	21.51	15.9
2000	14.53	15.69	22.33	30.73	33.89	31.92	29.9	29.82	29.49	26.82	21.85	16.3
2001	13.66	17.72	23.11	28.76	32.42	31.25	30.9	30.43	30.08	27.36	21.51	16.6
2002	14.66	17.2	23.68	30.52	33.9	33.39	32.59	30.3	27.63	26.72	21.07	16.4
	13.89	17.15	22.71	29.37	33.04	32.68	31.07	29.41	29.07	26.26	20.88	15.61

Mean average in coldest month is 13.89oC and
mean average in coldest quarter is 15.55oC

Table 3 Mean Max Temparature (Degrees Centigrade)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	20.94	24.52	29.15	35.77	41.13	40.94	35.42	31.66	33.82	33.82	28.57	23.3
1996	21.63	24.62	31	36.74	39.4	37.64	34.64	31.74	33.43	32.8	27.48	22.3
1997	20.58	23.77	29.76	34.71	37.74	37.24	35.31	32.83	34	31.04	27.54	20.8
1998	20	24.49	28.38	36.79	40.76	38.98	34.86	32.98	34.08	33.28	29.11	23.4
1999	20.69	25.24	31.77	38.61	40.47	38.73	35.81	34.22	34.11	33.48	29.41	23.2
2000	21.68	22.91	29.86	38.27	41.02	37.73	34.1	33.62	34.41	33.76	29.75	23.6
2001	20.76	24.94	30.81	36.36	39.55	37.07	35.1	34.08	34.7	34.34	29.31	24.1
2002	21.81	24.41	31.21	38.12	41.03	39.2	36.79	34.1	32.52	33.75	28.97	23.9
	21.01	24.36	30.24	36.92	40.14	38.44	35.25	33.15	33.88	33.28	28.77	23.06

Appendix 2

Appendix 2
Estimation of Future Population

Year	Census Population	Arithmetical Progression			Incremental increase Method			Geometrical Increase Method		
		Increase	Average Increase	Projected Population	Incremental increase	Average Incremental increase	Projected Population	Rate of Growth	Geometric Average Rate of Growth	Projected Population
1951	49,260									
1961	55,248	5,988						0.12		
1971	71,266	16,018			10,030			0.29		
1981	102,837	31,571			15,553			0.44		
1991	146,262	43,425			11,854			0.42		
2001	211,983	65,721			22,296			0.45		
			32,545			14,933			0.31	
2011				244,528			259,461			278,148
2021				277,072			321,872			364,966
2026				293,345			358,677			418,061
2031				309,617			399,216			478,881
2041				342,161			491,494			628,352

Appendix 3

Appendix 3

Ward Wise Population Projection												Assumed Ward Growth	
Ward No.	Area in hectare	Population 2001	Density 2001	Projected Density Population				Projected Population				Population Density	% Decadal Increase
				2011	2021	2031	2041	2011	2021	2031	2041		
1	275.75	12,766	46.3	55.6	66.7	80.0	96.0	15,319	18,383	22,060	26,472	0-100	20.0
2	62.67	9,999	159.5	188.3	222.1	262.1	309.3	11,799	13,923	16,429	19,386	100-200	18.0
3	9.71	6,185	636.7	662.1	688.6	716.1	744.8	6,432	6,690	6,957	7,236	200-300	15.0
4	109.22	8,078	74.0	88.8	106.5	127.8	153.4	9,694	11,632	13,959	16,751	300-400	12.0
5	22.78	5,528	242.7	279.1	321.0	369.1	424.5	6,357	7,311	8,407	9,669	400-500	9.0
6	293.40	14,882	50.7	60.9	73.0	87.6	105.2	17,858	21,430	25,716	30,859	500-600	6.0
7	157.11	20,857	132.8	156.6	184.8	218.1	257.4	24,611	29,041	34,269	40,437	600-700	4.0
8	26.32	7,729	293.6	337.6	388.3	446.5	513.5	8,888	10,222	11,755	13,518	700-800	2.0
9	13.37	5,813	434.7	473.8	516.4	562.9	613.6	6,336	6,906	7,528	8,206		
10	22.38	7,122	318.3	356.4	399.2	447.1	500.8	7,977	8,934	10,006	11,207	Assumed Maximum Dencity	800 persons/hacta re
11	68.36	11,061	161.8	190.9	225.3	265.9	313.7	13,052	15,401	18,174	21,445		
12	10.38	5,852	564.0	597.8	633.7	671.7	712.0	6,203	6,575	6,970	7,388		
13	25.33	5,002	197.5	227.1	261.2	300.3	345.4	5,752	6,615	7,607	8,749		
14	10.05	7,253	721.6	736.1	750.8	765.8	781.1	7,398	7,546	7,697	7,851		
15	66.12	15,563	235.4	270.7	311.3	358.0	411.7	17,897	20,582	23,669	27,220		
16	6.08	5,140	845.0	800.0	801.0	802.0	803.0	4,866	4,872	4,878	4,885		
17	8.84	3,438	389.0	435.6	487.9	546.5	612.0	3,851	4,313	4,830	5,410		
18	16.34	4,745	290.5	334.0	384.1	441.8	508.0	5,457	6,275	7,217	8,299		
19	19.72	5,671	287.6	330.7	380.3	437.3	502.9	6,522	7,500	8,625	9,919		
20	9.18	8,713	949.5	800.0	800.0	800.0	800.0	7,341	7,341	7,341	7,341		
21	4.13	4,798	#####	800.0	800.0	800.0	800.0	3,301	3,301	3,301	3,301		
22	28.95	4,396	151.8	179.2	211.4	249.5	294.4	5,187	6,121	7,223	8,523		
23	48.33	6,893	142.6	168.3	198.6	234.3	276.5	8,134	9,598	11,325	13,364		
24	33.46	5,527	165.2	194.9	230.0	271.4	320.2	6,522	7,696	9,081	10,716		
25	33.31	7,638	229.3	263.7	303.3	348.7	401.1	8,784	10,101	11,616	13,359		
26	7.92	5,780	730.2	744.8	759.7	774.9	790.4	5,896	6,014	6,134	6,256		
27	14.39	5,554	385.9	432.2	484.1	542.1	607.2	6,220	6,967	7,803	8,739		
HMC	**1,403.60**	**211,983**	**151.0**	**169.3**	**193.3**	**221.3**	**254.0**	**237,655**	**271,291**	**310,577**	**356,502**		
Area	3,229.40			12.5	29.0	52.1	84.2	40,493	93,675	168,304	271,850		
Total	**4,633.00**						**135.6**	**278,148**	**364,966**	**478,881**	**628,352**		

Appendix 4

Appendix 4

Zone wise Flow Generation STPCapacity required and Pump KW for Sewage Pump Station

S. No	STP South					STP East				
	Total Requirement									
	Zone No.	Flow in MLD				Zone No.	Flow in MLD			
		Yr 2011	Yr 2021	Yr 2031	Yr 2041		Yr 2011	Yr 2021	Yr 2031	Yr 2041
1	1	5.3	7.1	9.5	12.5	4	3.9	4.6	5.4	6.4
2	2	6.6	7.3	8.1	9.0	6	1.0	2.7	4.8	7.8
3	3	10.7	12.4	14.3	16.5	7	0.6	1.6	2.8	4.6
4	5	0.9	2.2	4.0	6.5					
	8	0.5	1.4	2.5	4.0					
Total		**24.0**	**30.4**	**38.4**	**48.5**		**5.6**	**8.9**	**13.1**	**18.7**

Combined flow of Ultimate design year of 2041 for both STPs in MLD 67.2

Phase 1										
S. No	Zone No.	Flow in MLD for STP South				Zone No.	Flow in MLD for STP East			
		Yr 2011	Yr 2021	Yr 2031	Yr 2041		Yr 2011	Yr 2021	Yr 2031	Yr 2041
1	1	5.3	7.1	9.5	12.5	4	3.9	4.6	5.4	6.4
2	2	6.6	7.3	8.1	9					
3	3	10.7	12.4	14.3	16.5					
Total		**22.6**	**26.8**	**31.9**	**38**		**3.9**	**4.6**	**5.4**	**6.4**

Calculation for Pump KW for SPS

S. No	SPS	Year	Flow in MLD	Head in Mts	KW required at Average Flow	KW required at Peak Flow	KW required with 25%
1	South	2026	29.4	15	71	161	201
2	East		5.0	15	12	27	34
3	South	2041	48.5	15	118	265	332
4	East		18.7	15	45	102	128

Appendix 5

Appendix 5
Coefficient of Roughness for use in Manning's Formula

Type of Material	**Condition**	**n**
Salt glazed stone ware pipe	Good Fair	0.012 0.015
Cement Concrete Pipes (with collar joints)	Good Fair	0.013 0.015
Spun concrete pipes (RCC & PSC) with Socket Spigot Joints (Design Value)		0.011
Masonry	Neat cement plaster Sand and cement plaster Concrete steel troweled Concrete wood troweled Brick in good condition Brick in rough condition Masonry in bad condition	0.018 0.015 0.014 0.015 0.015 0.017 0.020
Stone work	(a) Smooth dressed ashlar (b) Rubble set in cement (c) Fine well packed gravel	0.015 0.017 0.020
Earth	Regular surface in good condition In ordinary condition With Stones and weeds In poor condition Partially obstructed with debris or weeds	0.020 0.025 0.030 0.035 0.50
Steel	Welded Riveted Slightly tuberculated With spun cement mortar lining	0.013 0.017 0.020 0.011
Cast Iron	Unlined With Spun cement mortar lining	0.013 0.011
Asbestos Cement		0.011
Plastic (Smooth)		0.011

Appendices 6, 7, 8 & 10

Appendix 6, Appendix 7, Appendix 8, and Appendix 10

Appendix 6: Velocities Required to Move Solid Particles of different Specific Gravities

Type of material	**Specific gravity**	**Velocity required to move (m/s)**
Coal	1.26	0.37 to 0.45
Coal	1.33	0.45 to 0.52
Brick bat	2.00	0.52 to 0.60
Chalk pieces	2.05	0.60 to 0.67
Brick bat	2.12	0.60 to 0.70
Brick bat	2.18	0.70 to 0.75
Piece of flint	2.65	0.75 to 0.80

Appendix 7: Velocities Required to Move Solid Particles of Different Materials

Type of material	**Velocity required to move (m/s)**
Angular stones	1
Round pebbles (12 mm to 25 mm diameter)	0.5 to 0.6
Fine gravel	0.3
Coarse sand	0.2
Fine sand	0.15
Fine clay and silt	0.075

Appendix 8: Non-scouring or Limiting Velocities in Sewers of Different Materials

Sewer material	**Non-scouring or Limiting Velocity (m/s)**
Vitrified tiles and glazed bricks	4.5 to 5.5
Cast iron sewers	3.5 to 4.5
Stone ware sewers	3.0 to 4.0
Cement concrete sewers	2.5 to 3.0
Ordinary brick-lined sewers	1.5 to 2.5
Earthen channels	0.6 to 1.2

Appendix 10: Minimum or Self-cleansing Velocities for sewers of Different diameters

Diameter of sewer (mm)	**Minimum or self-cleansing velocity (m/s)**
150 to 250	1.00
300 to 600	075
Above 600	0.60

Appendix 9

Appendix 9

General Specifications for Different Sewage Treatment Technologies - Per mld

S. No.	Assessment parameter	ASP	TF	WSP	UASB+FPU	UASB+EAS	MBBR	SBR	MBR	KT	OD
1	**Design**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Process Type	Aerobic	Aerobic	Anaero -Aero	Anaero –Aero	Anaero -Aero	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic
	Overall HRT (Complete Cycle)	12 - 14 hrs	13 - 14 hrs	8 - 15 days	1.4 - 2.4 days	14 - 16 hrs	8 - 12 hrs	14 - 16 hrs	12 - 14 hrs	NA	6 - 30 hrs
2	**Performance for parameters**										
	BOD, %	85 - 98	80 - 90	75 - 85	80 - 88	80 - 95	85 - 95	90 - 95	95 - 98	N/A	85 - 95
	COD, %	80 - 90	85 - 90	70 - 85	80 - 85	80 - 90	80 - 90	88 - 96	95 - 100	N/A	80 - 90
	SS, %	85 - 90	75 - 85	70 - 85	80 - 85	85 - 90	85 - 95	90 - 96	98 - 100	N/A	85 - 95
	DO, mg/l (Final Effluent)	< 2	< 2	< 2	< 1	< 2	< 2	< 1.5	< 2	N/A	< 2
	Faecal coliform, log unit	Up to 3 < 4	Up to 2 < 3	Up to 4 < 5	Up to 1 < 2	Up to 2 < 4	Up to 2 < 4	Up to 2 < 4	Up to 6 < 7	N/A	Up to 2 < 4
	Helminth Removal %	-	-	yes							
3	**Area Requirement**										
	Average Area (ha/mld)	0.18~0.2	0.16~0.2	0.8~1.0	0.17~0.2	0.11~0.14	0.05	0.03	0.08	2	0.22
4	**Works Cost**										
	Civil Works, % of Capital Costs	60 %	80 %	95 %	65 %	55 %	40 %	40 %	30 %	90 %	60 %
	E & M works, % of Capital Costs	40 %	20 %	5 %	35 %	45 %	60 %	60 %	70 %	10 %	40 %
5	**Annual Repair Cost**										
	Civil Works Maintenance, % of Civil Works	1 %	1 %	0.5 %	1 %	1 %	1 %	1 %	1 %	2 %	2 %
	E & M Works Maintenance, % of E & M Works	3 %	3 %	0.5 %	3 %	3 %	3 %	3 %	15 %	1 %	2 %
6	**Daily Energy Requirements**										
	Avg. Process Power (kWh)	225	187.50	4.00	30.00	75.00	282.50	250	300	3.00	225
	Avg. Non-Process Power (kWh)	7.50	7.50	5.50	7.50	7.50	4.50	4.50	4.50	4.00	7.50
	Total Power Requirement, (kWh)	232.5	195	9.50	37.50	82.5	287.0	254.50	304.5	7.00	232.5
7	**Daily Energy Cost**										
	Power Cost @ Rs 5.0 per kWh	48.4	40.6	2.0	2.8	17.2	60.4	53.6	64.1	1.46	48.4
8	**Interest**										
	Rate of compound interest, (adopted), % per year	12	12	12	12	12	12	12	12	12	12
9	**Daily Bio Energy Generation**										
	Biogas Generation m^3	55 - 70	55 - 70	Nil	35 - 50	35 - 50	Nil	Nil	Nil	Nil	Nil
	Bio - Energy Generation (kWh)	25 - 35	25 - 35	Nil	20 - 30	20 - 30	Nil	Nil	Nil	Nil	Nil

Appendix 11

Appendix 11

Comparative Statement of Various Pipes for Gravity Sewers

S. No	Evaluation Criteria	Glazed Stoneware Pipes (IS:651-1980)	RCC Pipes (IS:458-1988)	uPVC Pipes	DI Pipes (IS:8329-2000)	HDPE Pipes (IS:14333 -2000)
1	Available Length	0.6m	2 to 2.5m	6 or 12m	6 m	6 or 12m
2	Diameters Available	100 to 300mm for higher diameters it is not economical.	150 to 2000mm	Available up to 630mm	Up to 1000mm	Available up to 630mm
3	Type of Joint	S&S joint with caulking yarn soaked in cement slurry or tarred gasket. Joint is covered with cement mortar.	Available in both collar and S&S joints.	Solvent Cement joint and Rubber Ring joint	Tyton joint with rubber gasket	Butt fusion welding process.
4	Weight	Light	Heavy	Light	Heavy but lighter than R.C.C. pipes.	Light
5	Handling	Easy due to shorter length and light weight	Difficult due to heavy weight	Easy due to light weight	Difficult due to heavy weight in larger dia	Easy due to light weight
6	Roughness Coefficient of Pipe	0.012	0.011	0.011	0.011	0.011
7	Corrosion resistance	Not affected by hydrogen sulphide gas. Highly corrosion resistant	Subject to H2S corrosion due to acids, highly septic sewage and by highly acidic or high Sulphate soils and where velocities are not sufficient to prevent septic conditions. To prevent corrosion Sulphate resistant cement concrete to be used for pipe manufacture.	Highly corrosion resistant	Protective layers are required to protect corrosion	Highly corrosion resistant
8	Life	More than 50 years	30 years	Life is more than 50 years due to highly corrosion resistant.	More than 50 years	Life is more than 50 years due to highly corrosion resistant.
9	Class of Pipes Available	Grade A & AA	NP1, NP2, NP3, NP4	6Kg/Sq.cm, 8Kg/	K-7 to K-12	PN 2.5, PN4, PN6, PN10

S. No	Evaluation Criteria	Glazed Stoneware Pipes (IS:651-1980)	RCC Pipes (IS:458-1988)	uPVC Pipes	DI Pipes (IS:8329-2000)	HDPE Pipes (IS:14333 -2000)
		(Non pressure pipes)	(Non pressure pipes)	Sq.cm,10Kg/Sq.cm,12Kg/Sq.cm	K-7= 12 - 32kg/sqcm. K-9= 25 - 50kg/sqcm Depending Upon the dia of pipe.	(2.5Kg/Sq, 4Kg/Sq, 6Kg/Sq and 10Kg/Sq)
10	Requirements of Special Equipments	Not required	Not required	Not required	Not required	Welding equipment required for jointing
11	Stacking the Pipe Materials	Can be stacked anywhere. Care should be taken while loading, unloading and stacking.	Can be stacked anywhere. Care should be taken while loading, unloading and stacking.	To avoid exposure to sunlight, it is stacked in covered area. This also requires a special type of stacking to avoid buckling and damage of pipe ends Care should be taken while loading, unloading and stocking.	Can be stacked anywhere. Care should be taken while loading, unloading and stocking.	Same as uPVC
12	Cost of supplying, laying and jointing of meter length	200 mm: Rs. 272 250 mm: Rs: 377 300 mm: Rs: 517 (DSR 07 + 10% Price contingency)	(NP3 Pipe) 350mm: Rs. 1134 400mm: Rs. 1234 500mm: Rs. 1568 600mm: Rs. 2102 NP2 Pipe 200 mm: Rs 248 300 mm: Rs 441 400 mm: Rs 578 500 mm: Rs 855 600 mm: Rs 1095 (UP JN)	6 kg/cm2 200mm: Rs. 604 (UPJN+20% for laying & Price Contngency) 315mm: Rs. 1448 (MP ADB Project+20% Price contingency)	(25 - 50 kg/cm2) K9 Pipe 200mm: Rs:2442 300mm: Rs:4505 400mm: Rs:5520 500mm: Rs:9418 600mm: Rs:12283 (UPJN Supply rate+20% for laying & price contingency)	PE 100, PN- 6 200mm: Rs. 640 315mm:Rs. 1585 400mm: Rs. 2595 500mm: Rs. 4695 630mm: Rs. 7434 (MP ADB Project+20% Price contingency)
13	Remarks on Cost	Comparatively Cheaper	NP2 is Cheapest among all materials	Costlier than RCC pipe but cheaper than HDPE pipes.	Costlier than other pipes but cheaper than HDPE pipes.	Smaller diameter pipes are cheaper and higher diameter pipes are costlier.
14	Requirement in Refilling the Trench	No stone or rock to be filled while refilling.	No stones or rocks to be filled while refilling.	Sand bedding is required to avoid the deflection of pipe due to burden of earth. No stones or rocks to be filled	No stones or rocks to be filled while refilling.	Concrete arch bedding is required to avoid the deflection of pipe due to burden of earth.

S. No	Evaluation Criteria	Glazed Stoneware Pipes (IS:651-1980)	RCC Pipes (IS:458-1988)	uPVC Pipes	DI Pipes (IS:8329-2000)	HDPE Pipes (IS:14333 -2000)
				while refilling.		
15	Infiltration	If joints are week/poor, chance of infiltration is high due to more number of joints.	Infiltration is less if rubber joints are used but joints should be proper if collar joints are used.	Infiltration is very less	Infiltration is very less	Infiltration is very less
16	Workability	Light weight for easy handling.	For larger diameter due to heavy weight handling to be done with care	Light weight for easy handling.	Good	Light weight for easy handling.
17	Effect of Radiation	Not affected	Not affected	Affected by UV rays if stored for a long duration in open fields hence it should be kept covered.	Not affected	Affected by UV rays if stored for a long duration in open fields hence it should be kept covered.
18	Jointing Skill Requirements	Requires quality supervision	Jointing is easy in S&S pipes with rubber ring joints.	Jointing is easy in S&S pipes using solvents.	Jointing is easy in S&S pipes with rubber ring joints.	Jointing is expensive and jointing results in beeding which causes obstruction for solids in sewage
19	Protection to the Pipe	Depending upon the loading conditions, pipes should be protected with either sand or Cement Concrete bedding	Depending upon the loading conditions, pipes should be protected with either sand or Cement Concrete bedding	Pipe should be protected against deflection due to super imposed loads. Pipe embedded portion should be well compacted.	Not required	Pipe should be protected against deflection due to super imposed loads. Pipe embedded portion should be well compacted.
20	Maintenance	Almost nil if joints are properly made.	Almost nil if proper velocity is maintained.	Pipe may get damaged due to rodding	Minimum	Pipe may get damaged due to rodding
21	Previous Experience/Performance	In use for long period and performance is satisfactory	In use for long period and performance is Good	Not common for street sewers but now picking up use to connect houses to sewer	It is durable pipe. Performance is yet to be proven	Recent use started in India. It is durable

Appendix 12

Appendix 12
Comparative Statement of Various Pipes for Rising Main

SI NO	Evaluation Criteria	HDPE Pipes (IS: 14333-2000)	Cast Iron Pipe (IS:1536-1989)	Ductile Iron Pipe (IS:8923-2000)	PSC Pipe (IS: 784 1989)
1.	**Type & Weight**	Light and Flexible	Heavy and Rigid pipe	Flexible and 30% less weight than CI "LA" class pipe	Heavy & Rigid Pipe
2.	**Cement mortar lining**	Not required	Not required	DI pipe with Sulphate resistant cement or high Alumina cement mortar lining is used for sewer lines	Not required
3.	**Strength**	High strength, but low impact resistance	High strength but low impact resistance.	High strength and high impact resistance.	High Strength and high impact resistance
4.	**Corrosion resistant**	High corrosion resistant, no protection is required.	High corrosion resistant, no protection is required.	Protection required to prevent corrosion.	Corrosion resistant
5.	**Jointing**	Butt fusion Jointing	Flexible rubber - push on type joints and flanged joints.	Flexible rubber -push on type joints and flanged joints. .	Flexible rubber push on type joints
6.	**Life (Approximate)**	Minimum 50 years	Minimum 50 years	More than 50 years	20-30 year
7.	**Workability**	Easy installation	Easy installation	Easy installation	Easy installation
8.	**Protection to the pipe**	Pipe should be protected against deflection due to super imposed loads and should be protected with either sand or Cement Concrete bedding.	Depending upon the loading conditions, pipe should be protected with either sand or Cement Concrete bedding	Depending upon the loading conditions, pipes should be protected with either sand or Cement Concrete bedding	Can withstand impact load.
9.	**Class of Pipes Available**	PN 2.5, PN4, PN6, PN10 (2.5 kg/sqcm, 4.0 kg/sqcm, 6.0 kg/sqcm, 10.0 kg/sqcm)	Class LA, A & B (10 kg/sqcm, 12 to 12.5 kg/sqcm, & 16 to 25 kg/sqcm) depending upon the dia of pipes.	K-7= (12 to 32 kg/sqcm) K-9= (25 to 50 kg/sqcm)	Can withstand 6 Kg/cm^2 to 20Kg/cm^2
10	**Value of C**	150 for New pipes	130 for New pipes. (100 for design)	140 for New pipes	140 for new pipes
11	**Cost of supplying, laying and jointing per meter length**	PE 100, PN- 6 200mm: Rs. 640 315mm:Rs. 1585 400mm: Rs. 2595 500mm: Rs. 4695 630mm: Rs. 7434 (MP ADB Project+20% Price contingency)	Class LA 200 mm 2966 300 mm 5182 400 mm 7964 500 mm 11404 (UPJN+20% for L & J & Price Contingency)	(K-9 Pipe) 200mm: Rs:2442 300mm: Rs:4505 400mm: Rs:5520 500mm: Rs:9418 600mm: Rs:12283 (UPJN Supply rate+20% for laying & price contingency)	800 mm Rs 5348 900 mm Rs 6056 1000 mm Rs 6881 1100 mm Rs 7591 (MP ADB Project+20% Price contingency)

Appendix 13

Appendix 13

Life Cycle Cost Analysis for Different STP Technologies (Per MLD, Amount in lakh Rs)

Parameters	**ASP**	**TF**	**WSP**	**UASB+FP**	**UASB+EA**	**MBBR**	**SBR**	**MBR**	**KT**	**OD**
Capital Cost	100.00	70.00	40.00	83.00	84.00	90.00	120.00	171.00	10.00	62.00
LA Cost	17.40	17.40	69.60	16.10	10.88	4.35	2.61	6.96	174.00	19.14
Total Capital Cost	117.40	87.40	109.60	99.10	94.88	94.35	122.61	177.96	184.00	81.14
Annual O&M Cost	6.59	5.32	1.16	2.99	3.68	8.14	8.21	10.01	0.51	6.14
Annual Resource Recovery	0.33	0.34	0.06	0.25	0.25	0.01	0.14	0.14	0.15	0.14
Annual Costs(O&M-Resource recovery)	6.26	4.98	1.10	2.74	3.43	8.13	8.07	9.87	0.36	6.00
Total Life Cycle Cost (30 Years)	305.10	236.70	142.50	181.19	197.67	338.15	364.61	473.95	194.80	261.04
Net Present Value @ 12% Discount	154.90	117.94	114.49	112.55	113.22	146.05	171.63	236.10	185.84	119.62
Capital Recovery Factor, CRF (12% intrest Rate & 30 years repayment period)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Annual Capital Investment Recovery Requirement	15.78	11.75	14.73	13.32	12.75	12.68	16.48	23.92	24.73	10.91
Annual O&M Recovery Requirement	6.26	4.98	1.10	2.74	3.43	8.13	8.07	9.87	0.36	6.00
Annual Investment+ Annual O&M costs	22.04	16.72	15.83	16.05	16.18	20.81	24.55	33.78	25.09	16.90

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