Agra Smart City Mission

Sewerage system for ABD area

DPR

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LIST OF ABBREVIATIONS

ADB	:	Asian Development Bank
AWWA	:	American Water Works Association
bar	:	Pressure unit: 1 bar ~ 10 metres of water column
BIS	:	Bureau of Indian Standards
BHP		Brake Horse Power
BL		Bed Level
cm	:	Centimetre
BOD5	:	Biochemical Oxygen Demand at 5 days
CDP	:	City Development Plan
CPHEEO	:	Central Public Health and Environmental Engineering Organisation
d	:	Day
DBO	:	Design Build Operate
DI	:	Ductile Iron (material for pipelines and fittings)
DIN	:	Deutsches Institut für Normung (German Institute forNorms)
DMA	:	District Metered Area
DPR	:	Detailed Project Report
DRA	:	DRA Consultants Pvt. Ltd.
EIA	:	Environmental Impact Assessment
EMP	:	Environment Management Plan
ESR	:	Elevated Service Reservoir
GL	:	Ground Level
GoR	:	Government of Rajasthan
GoI	:	Government of India
Grontmij	:	Grontmij A/S, Denmark
hr	:	Hour
ha or Ha	:	Hectare
HDPE	:	High Density Poly Ethylene (material for pipelines)
HP	:	Horse Power; 1HP = 0.745699872 kW = 745.699872 Nm/s (Newton metre / second)
ISO	:	International Organisation for Standardisation
kg	:	Kilogramme
kg/h	:	Kilogramme per hour
KPI	:	Key Performance Indicator
km	:	Kilometre
kV		Kilovolt
kVA		Kilovolt Ampere
kW	:	Kilowatt
kWh	:	Kilowatt hour
l	:	Litre
L	:	Length
LEAP	:	Local Environmental Plan
LOS	:	Levels of Service
LSGD	:	Local Self Government Department – Govt. of Rajasthan
l/d or lpd	:	Litres per day
l/h or lph	:	Litres per hour
l/m or lpm	:	Litres per minute
lpcd or l/c/d	:	Litres per capita per day (referring to the consumption of water)
l/s or lps	:	Litres per second
m above MSL.	:	Metres Above Mean Sea Level
m	:	metre
m^2	:	square metre
m^3/d	:	cubic metres per day
m^3/hr	:	cubic metres per hour

MDDL	:	MinimumDraw Down Level
mld or MLD	:	Million Litres per day
mm	:	Milimetre
MWL	:	Maximum Water Level
NRW	:	Non-Revenue Water
NSLB	:	National Service Level Benchmark
NTU	:	Nephelometric Turbidity Unit
OD	:	Outer Diameter (refers to non-metallic pipelines)
RW	:	Raw Water
RWPS		Raw Water Pumping Station
OJT	:	On the Job Training
OHSR	:	Over Head Service Reservoir
OHT	:	Overhead Tank
OHASAS	:	Occupational Health and Safety Standard
O&M	:	Operation and Maintenance
PE	:	Poly Ethylene (material for pipelines and fittings)
PI	:	Performance Indicator
PIU	:	Project Implementation Unit
PMDSC	:	Project Management, Design and Supervision Consultant
PMU	:	Programme Management Unit
PN	:	Nominal Pressure (normally followed by a number that represents bar)
PPTA	:	Project Preparatory Technical Assistance
PRV	:	Pressure-Reducing Valve
PSP	:	Public Stand post
ppm	:	parts per million = milligrams per litre
PVC	:	Poly Vinyl Chloride (material for pipelines and fittings)
RCC	:	Reinforced Cement Concrete
RF	:	Resettlement Framework
RP	:	Resettlement Plan
RWR	:	Raw Water Reservoir
SCADA	:	Supervisory Control And Data Acquisition
SDR	:	Standard Dimension Ratio for [HDPE pipes] (outer diameter / pipe wall thickness)
SEIAA	:	State Environment Impact Assessment Authority
SS	:	Suspended Solids
STC	:	Shah Technical Consultants
STP	:	Sewerage Treatment Plant (or WWTP)
TA	:	Technical Assistance
LAC	:	Local Administrative Committee
ToR	:	Terms of Reference
TM	:	Transmission Main
TSS	:	Total Suspended Solids
TW	:	Treated Water
TWPS	:	Treated Water Pumping Station
UFW	:	Unaccounted for Water
ULB	:	Urban Local Body
VAT	:	Value Added Tax
WDS	:	Water Distribution Station
WHO	:	World Health Organization
WTP	:	Water Treatment Plant(or) Willingness to Pay

EXECUTIVE SUMMARY

The Smart Cities Mission of the Government is a bold, new initiative. It is meant to set examples that can be replicated both within and outside the Smart City. Agra is one of 13 smart cities selected in Utharpradesh under "Smart City Mission". The ABD area is earmarked for about 2250 Acres comprising wards of 7, 71, 72, 74, 80, 81, 85, & 86, along with Mayapur and KalalKheria villages.

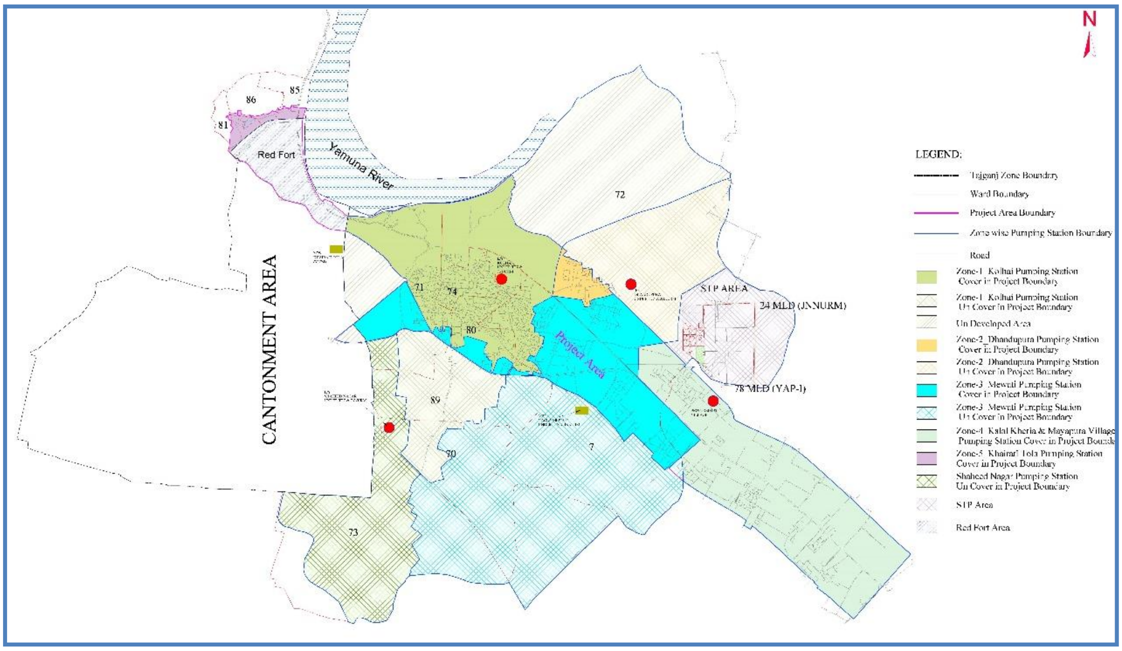
The Proposals

Providing sewerage system to the Area Based Development (ABD) is part of the Smart City Project. The objective is to ensure the 100% coverage of sewerage system in the ABD since TajMahal and its surroundings are significant tourist destinations and are in state priority. It is important to improve the sanitation conditions in this area, both to enhance its tourism potential, and to protect the area from environmental degradation.

Proposal for ABD

Present proposals are drawn for providing comprehensive sewerage system to the ABD.

- ✓ Total sewage generation of Tajganj Sewerage Zone including ABD is 25.99MLD for 2020, 37.62 MLD for 2035 & 54.87 MLD for 2050.
- ✓ About 28 Km length of sewers are proposed to cover the unsewered areas in the existing system.
- ✓ About 39 Km length of new sewers are proposed in Mayapur and KalalKheria villages.
- ✓ Sewage lifting stations with electrical and pumping machineries 1 No in zone Nagla Mewati, 1 No in zone Dhandupura is proposed & 1 No. in zone Kalalkheria & Mayapura villages
- ✓ Intermediate sewage pumping station (IPS) with electrical and pumping machineries for zone Kalalkheria & Mayapura village is proposed
- ✓ Sewage pumping main are proposed for a length of about 5.60 Km from Kolhai IPS and Kalalkheria & Mayapura IPS to proposed Jal Nigam 100 MLD capacity STP under Namami Gange project at existing 78 MLD exsiting STP campus.
- ✓ 12852 Nos. of House Sewer Connection (HSC) are proposed in the ABD.



Collection system

The ABD area falls in four existing zones namely Kolhai, NaglaMehwati, Dhandupura, & KhairatiTola and proposed zone for Kalalkheria & Mayapura villages. The collection system size varies from150mm to upto 450mm ID. Upto 300mm dia meter HDPE DWC pipe and above 300mm diameter RCC NP3 pipe are adopted. The zone wise sewer network pipe length is listed below

- Kolhai --- 10.94 Kms
- Nagla Mehwati ---- 12.65 Kms
- Dhandupura ---- 1.89 Kms
- Khairati Tola ---- 2.19 Kms
- Kalalkheria & Mayapura ---- 38.99 Kms

Lifting cum pumping stations

Lift stations are provided to interconnect the proposed unsewered area with existing collection system wherever the invert level of the last manhole is lower than existing connecting manhole. In Kalalkheria & Mayapura villages a lift station is proposed to restrict the depth of sewers within 6m depth.

In Nagla Mehwati Zone a lift station of M-LS is proposed to pump the sewage from proposed network to connect to the existing system. Further the sewage is also collected by gravity to the existing pumping station and conveyed by a pumping main to proposed STP.

In Dhandupura Zone, a lift station of D-LS is proposed to integrate the proposed sewer network with existing system. Further the sewage by gravity is collected at existing pumping station at Dhandupura.

Existing Nagla Mewati will continue to serve as MPS to pump sewage from Taj Ganj zone to existing 24 MLD sewage treatment plant.

Replacement of pumping plants proposed at Kolhai IPS will be executed at the fourth year of O&M period i.e at 2023-2024. Until 2023-2024 the existing system will continue.

In Kalalkheria & Mayapura villages a lift station is provided to restrict the depth of sewers within 6m and connected to nearest manhole to collect by gravity at proposed IPS at Tora

Sewage pumping main

As the existing capacity of STP is not adequate for TajGanj area intermediate sewage generation of 37.62 MLD. The sewage from Kolhai and Kalalkheria & Mayapura villages are proposed to treat at newly proposed 100 MLD STP by Jal Nigam under Namami Gange scheme.

From Kolhai intermediate pumping station (IPS), 600mm diameter DI-K7 pumping main for a length of 3.79 Kms to proposed STP site and from Kalalkheria & Mayapura villages IPS 200 mm diameter DI-K9 pumping main for a length of 1.82 Kms are proposed.

Sewage treatment plant

The estimated sewage generation for 2035 is 37.62 MLD and existing STP of 24 MLD will continue to treat the sewage upto its full capacity. The additional sewage generated from Kolhai and Khalalkeria zones will be treated at proposed 100 MLD capacity STP by Jal Nigam at the existing 78 MLD STP site.

Consumer Connections

A provision has been made for providing about 12,852 consumer connections in ABD area for left out connections in existing system and for proposed network. House sewer connections are proposed with DWC HDPE pipe of 110mm & 160mm with a connecting chamber for each household.

Operation and Maintenance

Refers to the procedures and activities involved in the actual delivery of services, e.g. collection of sewage, pumping, transmission and treatment of sewage. It includes the planning and control of the collection, treatment, and disposal of effluent. It also covers the management of client and public relations, legal, personnel, commercial, and accounting functions.

Keeping existing capital assets in serviceable condition, e.g. by repairing collection sewers, pumps and sewage treatment plants. Maintenance deals with activities that keep the system in proper working conditions including management, cost recovery, repairs and preventive maintenance. Maintenance involves Preventive and Predictive maintenance.

	Sewerage system in ABD Area	
	General Abstract	
Sl No	**Description**	**Amount in Rs.**
1	**Collection System**	
	Kolhai IPS	62,490,951.00
	Dhandapura IPS	10,713,731.00
	Mewathi MPS	85,536,028.00
	Central MPS	11,197,618.00
	Village IPS	249,039,494.00
2	**Pumping Main**	
	Kolahi to SPS to STP	8,079,334.90
	New SPS to Kalalkeria	2,832,633.00
	Dhandupura LS to D EMH 42	907,492.00
	Mewati LS to M EMH 134	209,155.00
	New SPS to STP	8,079,334.00
3	**Lift Station**	
	Village LS	464,275.00
	Dhandupura LS	451,831.65
	Mewati LS	4,190,500.62
	Valve Chamber	431,479.00
4	**Pumping Station**	5,319,337.00
5	**Control Room**	
	Lift Station	219,868.00
	Village LS	464,275.00
	Dhandupura LS	451,831.00
	Mewati LS	419,050.00
	Pumping Station	392,259.00
6	**Rehabilitation of Existing Sewerage system**	6,323,724.00
7	Miscellaneous items like Sewer cleaning equipment,safety equipment, minor tool kits and other major equipment	12,280,000.00

8	**Mechanical Arrangements**	
	Lift Station	
	Village LS	1,106,616.00
	Dhandupura LS	1,501,694.00
	Mewati LS	1,490,383.00
	Pumping Station	
	Kolhai SPS 1	8,763,219.00
	Kolhai SPS 2	6,523,288.00
9	**Electrical Arrangements**	
	Lift Station	
	Village LS	694,231.00
	Dhandupura LS	368,201.00
	Mewati LS	345,157.00
	Pumping Station	
	Kolhai SPS 1	10,422,394.00
	Kolhai SPS 2	3,179,258.00
10	**Provision for trenchless crossing of sewers for about 150mts.**	2,730,000.00
11	Shifting of Utility (All type of utilities like Power cable, Telephone, Water Supply & sewerage) (Payment will be calculated as per actual work done with relevant SOR of PWD & Jal Nigam).	40,969,132.11
12	**Operation & Maintenance**	
	Year 2020-2021 (Partial Completion)	22,211,500.00
	Year 2021-2022	46,644,000.00
	Year 2022-2023	48,976,000.00
	Year 2023-2024	51,425,000.00
	Year 2024-2025	53,996,000.00
	Year 2025-2026	66,300,000.00
13	**Laying of Vaccum Sewerage System including 5 years operation and maintenance cost**	66,300,000.00
	Sub Total	**90,44,40,274.28**
	GST 12%	10,85,32,832.91
	Labour Cess about 1%	90,44,402.74
	Total	**102,20,17,509.93**

1. INTRODUCTION

Agra is one of 13 cities selected for smart city mission by Govt. of India, ABD area is earmarked based on selection criteria as follows

- The city profile
- Citizen opinion and engagement
- Opinion of the elected representatives
- Discussion with the urban planners and sector experts
- Discussion with the suppliers/ partners

The ABD area in Agra covers about 2.40 % of total Municipal corporation area. Two villages KalalKheria and Mayapura located adjacent to the Municipal limit are also added to ABD area. The details of ward wise coverage is tabulated below

1.1 Location and Area

Agra city is located on the southern bank of River Yamuna. It is a northern part of Uttar Pradesh, India. The state capital Lucknow is about 378 Km on east. Agra is near national capital New Delhi about 206 Kms northwest direction. The city is also well connected with National highways, rail networks to other major cities and district headquarters.

Agra is a major tourist destination because of its many Mughal-era buildings, most notably the Tāj Mahal, Agra Fort and Fatehpur Sikri, all three of which are UNESCO World Heritage Sites. Agra is included on the Golden Triangle tourist circuit, along with Delhi and Jaipur; and the Uttar Pradesh Heritage Arc, tourist circuit of UP state.

The climate of Agra experiences mild winters, hot and dry summers and a monsoon season. Agra has a reputation of being one of the hottest towns in India. In summers the city witnesses a sudden surge in temperature and at times, mercury goes beyond the 46°C mark in addition to a very high level of humidity. During summer, the daytime temperature hovers around 46-50°C. Nights are relatively cooler and temperature lowers to a comfortable 30°C. Winters are bit chilly but are the best time to visit Agra. The minimum temperature sometimes goes as low as 2 or 3°C but usually hovers in the range of 6 to 8°C. The location of Agra city and SCM-ABD Area is show Fig. 1 below.

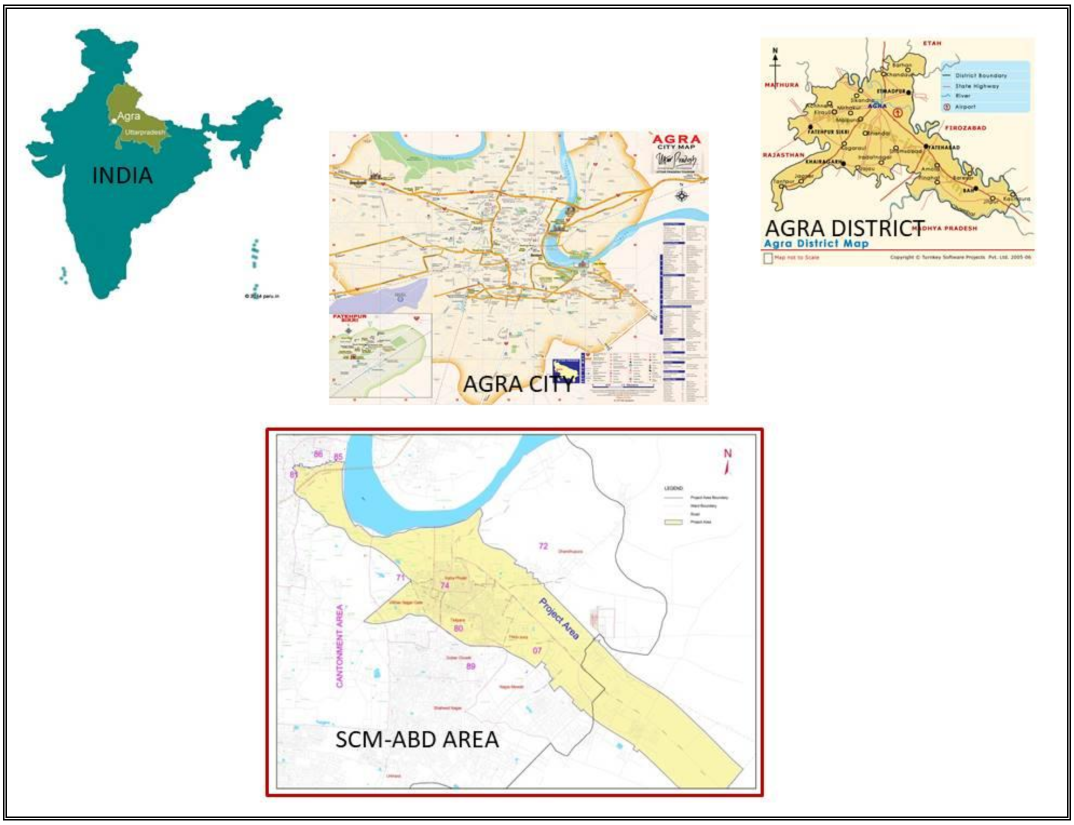


Figure 1: ***Location of Agra city and SCM-ABD Area***

1.2 Demographics

Agra is a major tourist destination because of its historical Mughal-era buildings, three historical monuments are earmarked for UNESCO World Heritage sites.

1. Taj Mahal,
2. Agra Fort
3. Fatehpūr Sikrī,

Agra City with a total land area of 141 km^2 had a population of 2, 22,943 in 2011. The growth rate of Agra varies from decade to decade and last three decade the growth rate is increasing. In last six decades the population has grown almost 4.75 folds, with increase in population from 3,33,530 in 1951 to 15,85,704 in year 2011. The growth pattern of the town is illustrated in the Table1:

Table 1:Decadeal Population and Growth Pattern

Sl.No.	Year	Population		Decadal Growth rate Population Variation %
		Population	Variation	
1	1951	333530		
2	1961	462020	128,490	39%
3	1971	591917	129,897	28%
4	1981	694191	102,274	17%
5	1991	891790	197,599	28%
6	2001	1275134	383,344	43%
7	2011	1585704	310,570	24%

Agra recorded an overall literacy rate of 60.10 % with female literacy of 40.96%, Thus Agra compares favourably in terms of literacy and sex ratio compared to state averages on these indicators.

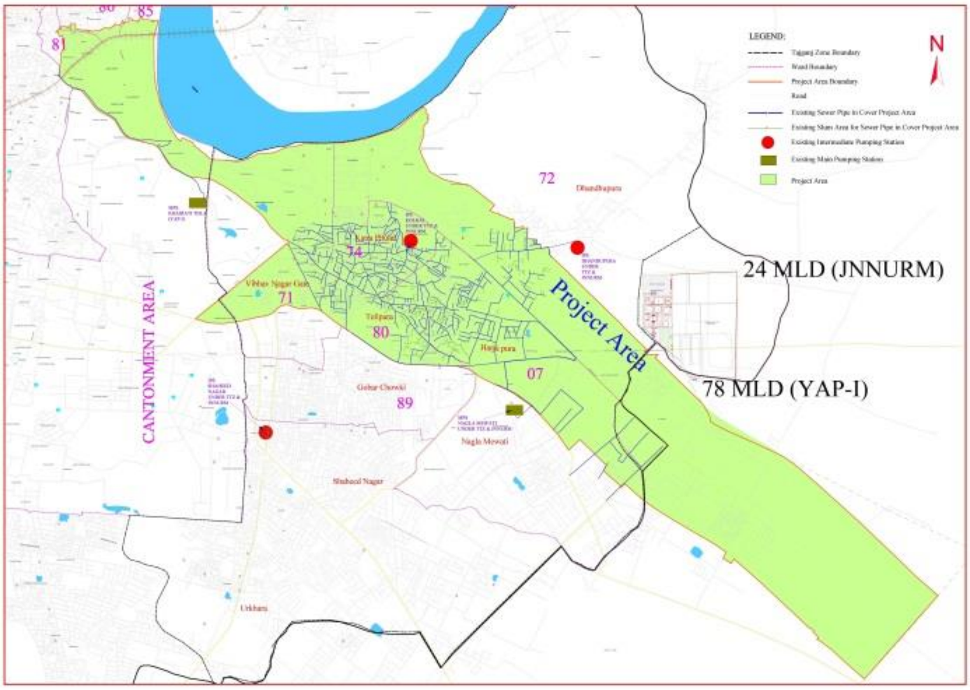
1.3 Objectives of the assignment

The objective is to ensure the 100% coverage of sewerage system in the ABD since Taj Mahal and its surroundings are significant tourist destinations and are state priority. It is important to improve the sanitation conditions in this area, both to enhance its tourism potential, and to protect the area from environmental degradation.

2. EXISTING SYSTEM OVERVIEW

2.1. Existing Sewerage System

The sewerage system for Agra city has been provided by UP Jal Nigam under JNNURM and TTZ schemes. ABD falls under sewerage network zones of Tajganj and Central Zone. The sewage generated from Taj Ganj zone is collected into four existing pumping stations namely Kolhai, Shaheed Nagar, Dhandupura and Nagla Mewati. Nagla Mewati is serving as master pumping station. The sewage by pumping from all three pumping stations is collected at Nagla Mewati and then pumped to 24 MLD STP at Dhandupura.



2.1.1. Collection System

Total length of existing sewer network provided in ABD is about 53.24 Km with a pipe diameter ranging from 150mm to 1000mm. Zone wise existing sewer network in ABD area is provided in the table below.

Ward wise sewer network coverage is provided in table below and the images show the existing sewer network in the ABD. House Sewer Connection (HSC) work is under progress.

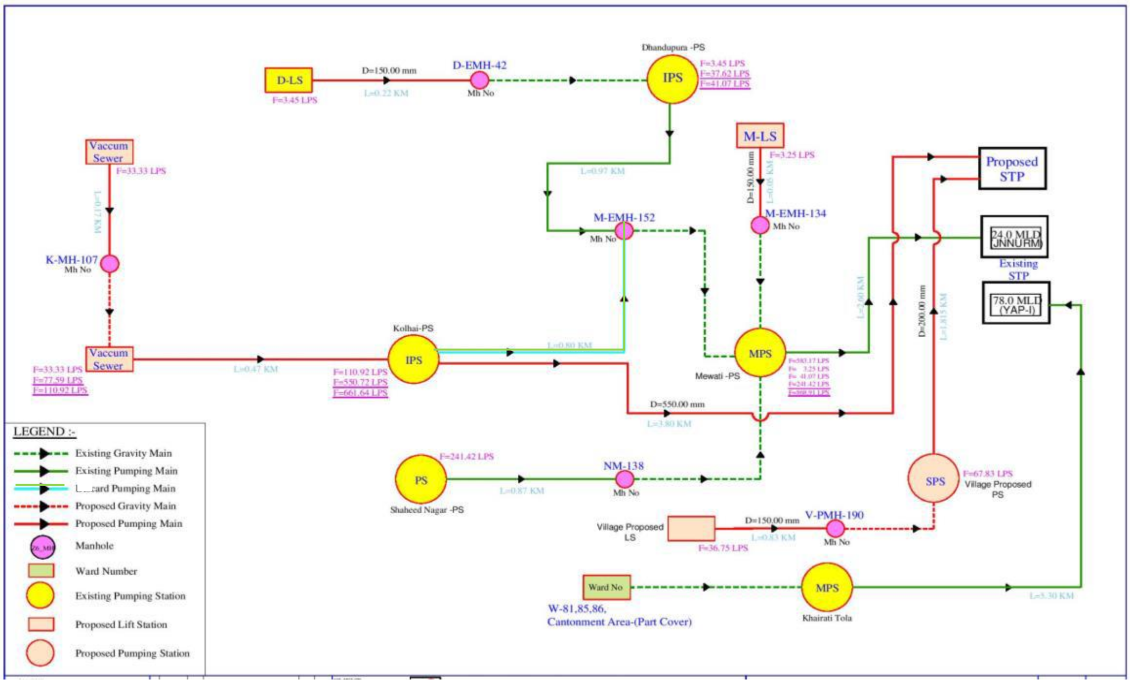
Table 2: Ward wise sewer network

Sl. No	Ward No	Existing Sewer Length in m		
		Slum Area Sewer	Other Area Sewer	Total
1	Ward -7	2773	17581	20354
2	Ward -71	561	5743	6305
3	Ward -72	1850	6102	7952
4	Ward -74	280	7326	7606
5	Ward - 80	1848	9138	10987
6	Ward - 81		846	846
7	Ward - 85		470	470
8	Ward - 86		1717	1717
Total		**7313**	**48924**	**56237**

2.1.2. Sewage Pumping Stations (SPS)

Kolhai SPS Sewage from Ward 74 & 80 and Part of Ward 7, 70, 71, 72 & 89 are collected in Kolhai SPS and conveyed through 500mm dia D.I K7 pipe to Gravity Main of NaglaMewati MPS gravity main.		
Saheed Nagar SPS Sewage from part of Wards 70, 71, 73 & 89 are collected in Saheed Nagar SPS and conveyed through a pumping main to Gravity Main of NaglaMewati MPS gravity main.		
NagalaMewati MPS Sewage from part of Wards 7, 70, 72, 73 & 89 are collected in Mewati SPS and conveyed through 800mm DI k7 pumping main to 24 MLD STP located at Dhandupura.		

2.1.3. Pumping Main



Sewage collected from the pumping stations further conveyed to the Main Sewage Pumping Station (MPS) located at Nagla Mewati for preliminary treatment and subsequently pumped to 24 MLD Sewerage Treatment Plant (STP)

2.1.4. Sewerage Treatment Plant (STP)

Total sewage from Tajganj Zone has been conveyed from the Main pumping station located at Mewati to 24 MLD Sewerage Treatment Plant (STP) of UASB with EAS process technology located at Dandhupura. Presently about 20 MLD of sewage is received by this plant for treatment. Treated effluent from this plant is disposed in River Yamuna through an open channel.		
		

3. NEED FOR THE PROJECT

3.1. Need for the project

The existing sewerage system in ABD area is commissioned under JNNURM and TTZ schemes. The existing system needs improvements to address the following deficiency in the existing system

- To achieve 100% covereage of sewerage fascility for the project area, additional sewer lines need to be laid in recently developed areas and uncovered areas and connect to the existing system
- House service conenctions are not provided for all households resulting in disposal of sewage into storm water drains and thereby polluting surface water. To restore river Yamuna and other surface drains it is essential to implement 100% house sewer connections
- The existing sewer system has some blockages in the collection system. The manholes upstream of the blockages are overflowing to road side drains. So, it is vital to identify the blockages of the existing sewer system and rectify by desilting the manholes, cleaning the sewerline with jet roding machines and retrofitting the damages in the existing manholes and sewerlines.
- There is existing 24 MLD STP at Dandupura for Taj Ganj Zone. If the existing sewerage system is upgraded the capacity existing STP is not adequate for 2020. So, It is needed to lay pumping main from proposed sewage pumping station at Tola for kalalkeria & Mayapura villages and further divert the flow from Kolhai sewage pumping station to proposed STP.
- To achieve better treatment standards a new STP wit SBR technology is needed to reuse the treated effluent or dispose to surface water body.

All the deficiencies need to be addressed in this project. So, by implementing this project the entire sewerage system will be improved and thereby sewage pollution caused to Taj East drain and river Yamuna shall be minimised to greater extent. This project will give roadmap for revamping the sewerage system for entire city.

3.2. Scope for the project

The efficiency of sewerage system has many challenges in collection, treatment and disposal into surface water body. So, there is a scope for improving the existing system with following improvement works

- Sewerage system for Kalalkheria and Mayapura villages with new sewage pumping staion with with one lifting station with pumping arrangments at Tola

- To identify sludge &silt deposition in the manholes and desilting with sewer cleaning equipment and disposal of sludge to sludge treatment unit
- To investigate the blockages in the existing sewerlines and cleaning the blockages by using sewer jet roding machines to enable flow of sewer to sewage pumping stations
- Retrofitting of sewer manholes with damaged brickwork and damaged plastering and bring back to original condition.
- Replacement of damaged pipelines by laying parallel pipes of same diameter and disconencting the existing damaged pipelines
- Constructing lift station with pumping arrangments to interconnect the existing system and to connect the newly developed areas and uncovered areas with existing system
- Laying of new pumping main with pumping arrangements from proposed sewage pumping staion at Tola to proposed STP and to lay a new pumping main from existing sewage pumping station at Kholai to proposed STP

4. POPULATION, SEWER GENERATION

4.1. Introduction

Agra Smart City Limited being part of this project have considered up-gradation of the entire water supply system including the Pumping stations, transmission system, distribution system and reduction of Non-Revenue Water (NRW) within the ABD area and therefore, the water supply system of the smart city project area. The population contribution of the project area is from ward no.7,71,72,74,80,81,85 & 86. Apart from the area under municipal limit, nearby two villages Kalal Kheria and Mayapura villages are also incorporated in ABD area. Hence to arrive at the demand of water for the design years, population projection for the design years has been arrived at as detailed below.

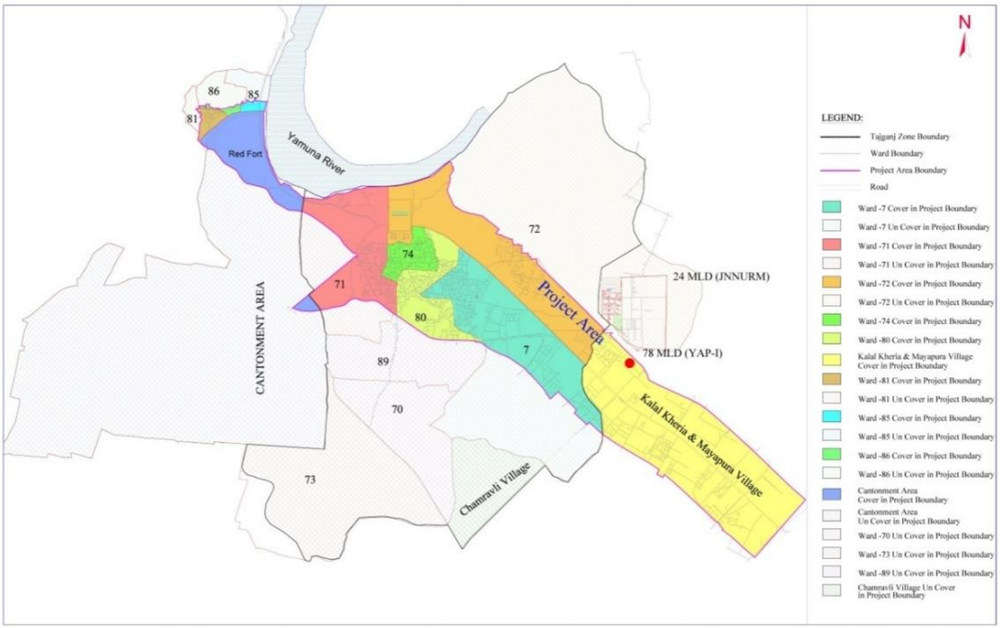


Figure 2: Ward Boundary

4.2. Population

The town has been growing steadily since 1951. The growth of the town has been phenomenal during 1951-81 However, thereafter also the growth was not stable. The average decadal increase is 30%. However, the last decadal (2001-2011) growth is only 24%, vide the Table below & Fig 3.

Table 3: ***Details of decadal population growth rate of Agra city***

Census Figures		Decadal % of Increase/Decrease
Decade year	**Population**	
1951	333530	
1961	462020	139%
1971	591917	128%
1981	694191	117%

Census Figures		Decadal % of Increase/Decrease
Decade year	Population	
1991	891790	128%
2001	1275134	143%
2011	1585704	124%

Population projection has been prepared for Agra project area based on different methods with census population for the year 2011 and past decades. Population projection has been done for 30 years for the year 2050 as per Guidelines in CPHEEO Manual. Population projections from different methods are as follows:

Table 4:*Population projection by various methods*

Calendar Year	Arithmetic Increase Method	Incremental Increase Method	Geometrical Progression Method	Line of Best Fit Method	Exponential Method
2018	1731791	1753459	**1891923**	1870682	1847121
2020	1773530	1804666	**1989814**	1967886	1929437
2035	2086574	2235152	**2904890**	2877398	2675747
2050	2399617	2747573	**4240791**	4207266	3710729
Density per Hec. for 2050	191	218	**337**	334	295

The population forecast has been calculated considering three above mentioned five methods. Based on population projection with different methods, population projection data with geometrical progression method is close. Therefore, population projection by Geometrical progression method has been adopted which is matching with the population growth trend in Agra

Table 5: *Projected population for ABD area by various stages of project*

Year	2011	2020	2025	2030	2035	2040	2045	2050
Population	82342	103327	117216	132971	150844	171121	194122	220214

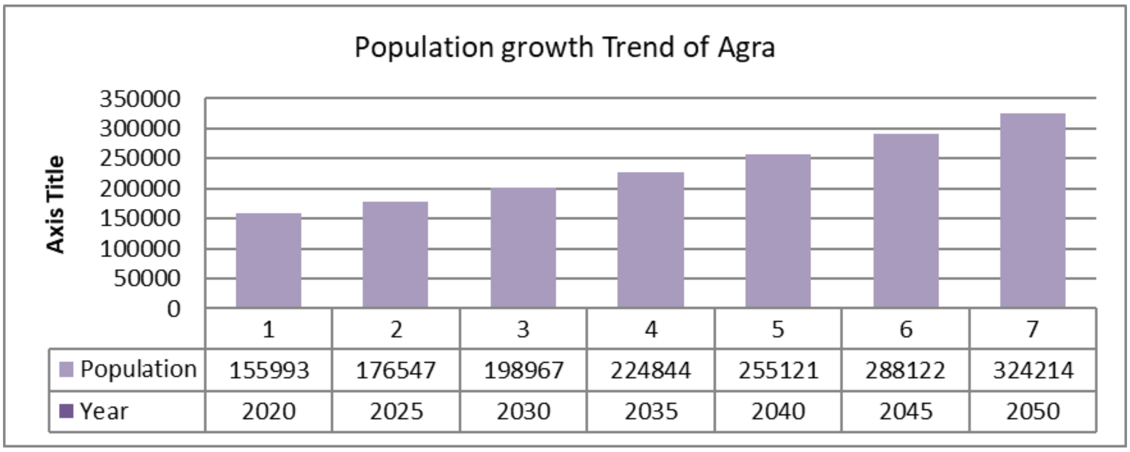


Figure 3: Population growth Trend of Agra

Table 6: ***Ward wise population projection for various stages of project***

Sl.No	Ward Number	% of coverage	Total ward Population 2011 (Nos)	Project area population in Nos.							
				2011	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
1	Ward -7 (P)	46%	19397	8851	11107	12600	14293	16214	18394	20866	23671
2	Ward -71 (P)	60%	17695	10581	13278	15062	17087	19384	21989	24945	28298
3	Ward -72 (P)	23%	8684	1992	2500	2836	3217	3649	4140	4696	5327
4	Ward -74	100%	25530	25530	32036	36342	41227	46769	53056	60187	68277
5	Ward - 80	100%	22570	22570	28322	32129	36447	41347	46904	53209	60361
6	Ward - 81 (P)	50%	5948	2976	3734	4236	4806	5452	6185	7016	7959
7	Ward - 85 (P)	20%	14741	2932	3679	4174	4735	5371	6093	6912	7841
8	Ward - 86 (P)	12%	12271	1468	1842	2090	2371	2689	3051	3461	3926
9	Kalal Kheria & Mayapura (Village)	100%	5442	5442	6829	7747	8788	9969	11309	12830	14554
			132278	**82342**	**103327**	**117216**	**132971**	**150844**	**171121**	**194122**	**220214**
10	Floating population for Taj Ganj-I				52666	59331	65996	74000	84000	94000	104000
	Total				**155993**	**176547**	**198967**	**224844**	**255121**	**288122**	**324214**

4.3. Sewage Generation of ABD and Tajganj Sewerage Zone

As per CPHEEO Sewerage Manual, 80% of the water may be expected to reach the sewers unless there is data available to the contrary. In ABD, it is proposed to supply the water at the rate of 150 LPCD. The expected flow of sewage be 120 LPCD.

Projected Population and Sewage Generation for Different Horizon years for ABD and Tajganj Sewerage Zone are tabulated below.

Project Area	Projected Population in Nos.			Sewage Generation @ 80% in MLD		
	2020	2035	2050	2020	2035	2050
ABD	106690	155168	226422	12.80	18.62	27.17
Tajganj Sewerage Zone	257960	373706	541534	25.99	37.62	54.87

5. SYSTEM SIZING AND DESIGN CRITERIA

5.1. Design Period

The design year is the year in the future upto which a scheme under formulation should give satisfactory service. The design year for the sewer is generally adopted as 30 years. In the present case, it may be assured that the sewer system for the town will start operating by 2020, which forms the base year. Therefore the ultimate design year is adopted as 2050. The intermediate design year shall be 2035 for the electrical, mechanical equipment for which the deign year is generally fixed as 15 years , the period upto which pump sets can be expected to perform satisfactorily without the frequent breakdowns or excess or loss of efficiency, necessitating replacement of the pump sets, with proper O&M.

- Base Year : 2020
- Intermediate Stage : 2035
- Ultimate Stage : 2050

5.2. Design year population

Having fixed the design year it becomes necessary to forecast the population of the town that will have to be served. The population forecast is generally done based on analysis of the population growths exhibited for 3 decades in the past.

5.2.1. Per Capita Sewage Flow

As per CPHEEO Sewerage Manual, 80% of the water may be expected to reach the sewers unless there is data available to the contrary. In ABD, it is proposed to supply the water at the rate of 150 LPCD. The expected flow of sewage be 120 LPCD, As the subsoil water table is below 20m, provision for infiltration is not considered.

5.2.2. Peak Factor

Peak factor is the ratio of maximum to average flows during a day. Computation of peak flow in design of the underground sewerage network is considered based on cumulative nodal population as per CPHEEO norms as furnished below;

Contributory Population	Peak Factor
Upto 20,000	3.00
20,000 – 50,000	2.50
50,000 – 750,000	2.25
Above 750,000	2.00

5.2.3. Hydraulics of Sewers

Flow in sewers is said to be steady, if the rate of discharge at a point in a conduit remains constant with time, and if the discharge varies with time, it is unsteady. The hydraulic analysis of sewers is simplified by assuming steady flow conditions. The design of wastewater collection system presumes flow to be steady and uniform. A properly functioning sewer has to carry the peak flow for which it is designed and transport suspended solids in such a manner that deposits in a sewer are kept to minimum during average flow. The unsteady and non-uniform wastewater flow characteristics are accounted for in the design by proper sizing of manholes.

5.2.4. Design Flow-Friction Formula

The available head in sewers due to elevation difference is utilized in overcoming surface resistance and, in small part, in attaining kinetic energy for flow. The design practice is to use the Manning's formula for open channel and the Hazen Williams or Darcy – Weisbach formula for closed conduit or pressure flow.

Manning's formula will be adopted for the design of sewers, as the gravity flow will be partial in the sewers.

$V=1/n * R^{2/3}*S^{1/2}$

$Q = A \times V$

Where,

Q = Discharge in (m^3/sec)

A = Cross-sectional area in (m^2)

S = Slope of hydraulic gradient

D = Internal dia of pipeline in (m)

V = Velocity in (m/sec)

R = Hydraulic radius in (m)

n = Manning's coefficient of roughness

5.2.5. Manning's Coefficient of Roughness

Manning's roughness coefficient varies with the type of pipe material used in sewer construction. The roughness coefficient 'n' value of 0.010 for DWC PE and 0.011 for RCC pipes have been adopted in the design of sewage collection system as per Chapter 3 of CPHEEO manual.

5.2.6. Minimum Diameter of Pipe

As per CPHEEO manual minimum size of sewer of 200 mm has been considered in the design of sewage collection system. However to connect with existing 150mm dia and achieve minimum velocity, minimum 150mm has been adopted.

5.2.7. Minimum Depth of Cover

To facilitate connection of house sewers to branch sewers and provide protection to sewers from external loads, the minimum depth of cover on any proposed sewers will be 1.0 m. However, in some starting laterals cover is restricted to 0.80 m to avoid uneconomical depth of cut in subsequent reaches. As the traffic over this header areas are limited and tonnage is less, this will not cause any problem in system operation.

5.2.8. Maximum Allowable Depth of Sewer

Generally, the maximum depth of seweris 8.0 m as per current practice; however, since the system is to be integrated with the already laid system, considering the ground conditions the depth is restricted to minimum level. To avoid the public inconvenience during execution and safety aspects it is proposed to lay sewer with trenchless technology where lane width is about 5.0 m and sewer depth is more than 3.5 m, important circles in the city where traffic density is more, in the streets where traffic diversion is not feasible.

5.2.9. Self-Cleansing Velocity

Sewers have been designed to maintain flow velocities more than 0.80 m/sec (for ultimate peak flow) and 0.60 m/sec (for present peak flow) to avoid silt deposition and ensure self-cleaning velocity in sewers. The flow in sewers varies widely from hour to hour and also seasonally, but for the purpose of hydraulic design, it is estimated that peak flow is adopted. However, it is to be ensured that a minimum velocity is maintained in the sewers even during minimum flow conditions. Hence in laterals, the slope suggested by CPHEEO for maintaining a self-cleansing velocity of 0.60m/sec has been adopted.

Dia. in mm	Slope 1 in	
	Min	Max
200	250	175
250	360	300
300	450	340
350	670	460
400	700	500

Maximum velocity in a sewer is so adopted as not to exceed 3.0 m/s as it would result in its erosion caused by sand and grit. However wherever self-cleaning velocity couldn't be arrived periodical flushing from head manhole is recommended

5.2.10. Maximum Allowable Depth of Flow

Sewers have been designed for partial flow condition with not less than half full flow and also to carry estimated peak flows generated in the ultimate design year to run at not more than 0.8 full. This is to ensure proper ventilation and prevent septicity.

5.2.11. **Sizing of Sewers**

It is necessary to size the sewer to have adequate capacity to carry the peak flow to be achieved at the end of design periods, so as to avoid steeper gradients and deeper excavations. It is desirable to design sewers for higher velocities wherever possible. This is done on the assumption that although silting might occur at a minimum flow, the silt would be flushed out during the peak flows. However, the problem of silting may have to be faced in the early years particularly for smaller sewers which are designed full flow part full at the end of design period, where depth of flow during early years is only a small fraction of the full depth. Similarly, upper reaches of the laterals pose a problem as they flow only partly full even at the ultimate design flow, because of necessity of adopting the prescribed minimum size of sewer. In such situations flushing arrangements may have to be provided in the initial years. After arriving at slopes for present peak flows, the pipe size has been decided on the basis of ultimate design peak flow and permissible depth of flow. The minimum diameter of pipe size adopted in the design is 150mm with the point of view to achieve velocity to overcome silt deposition in the sewer system.

5.2.12. Pipe Materials

The appropriate choice of pipe material would undoubtedly make a remarkable contribution to the conventional centralized sewerage system. A sewerage system involves a series of conduits to be linked up for the conveyance of sewage from residential, commercial, and industrial areas, as well as rainfall or surface water. The sewage is transported under gravity (or via pumping facilities, when necessary) to a sewage treatment plant before discharging into water bodies. Consequently, high resistance to internal pressure is seldom required, and thus less expensive piping materials are used.

The following pipe materials have been considered:

a) Double Walled Corrugated (DWC) HDPE Pipe (Upto 300mm depth for a depth of 3.50m)- DWC-PE pipes shall conform to IS 16098 part-2. Specifically, the double wall corrugated (DWC) High Density Polyethylene (HDPE) pipe is a new product designed to accommodate all the properties required for wastewater and drainage system. The DWC HDPE is a new technology for India. As the name suggests, the pipe is double layered. The inner wall is smooth while the outer wall is corrugated. Its properties offer advantages for the transportation of waste material while offering good overload force bearing properties. This technology ensures that when the pipe is laid underneath a road, there is no damage to the pipe from the traffic on the road. This pipe is designed for only gravity flow applications like sewage and drainage but it can still withstand an internal pressure of 2.5 kg/cm^2 which enables periodic flushing and maintenance as required.

Advantage:

- Good resistance to corrosion attack.
- Relatively light weight
- Flexible
- Low frictional resistance
- Comprehensive range of fittings available
- Higher flexibility and flexural strength ensures its capabilities to sustain greater overburden as well as live load impact.
- Low, Maintenance, because of non-adherence of sewage elements on the chemically inert pipe surfaces, no chance or corrosion and zero to low damages.

Disadvantages:

- Compare to cost wise, costlier that other material
- In case of maintenance/replacement, getting new pipe for smaller quantity is difficult

b) Concrete Pipes (Above 300mm dia above 3.50m depth)- Concrete pipes can be manufactured to any reasonable strength required by varying the wall thickness and the percentage of reinforcement and shape of the reinforcing cage. Concrete pipes are manufactured as non-pressure pipes with classes of NP2, NP3 and NP4. They are manufactured in sizes from 200 mm to 2000 mm. However, these pipes are subjected to corrosion where acid discharges into sewer or where velocities are not sufficient to prevent septic conditions or where the soil is highly acidic or contains excessive sulphates. Protective linings or coatings should be used inside and outside where excessive corrosion is likely to occur. The pipes may be manufactured with sulphate resistant cement. Only high alumina cement lining should be given where the pipes are exposed to corrosive sewage or industrial wastes.

Advantages of Concrete Pipes

- Providing the required strength to the pipes may be relatively easier.
- With Socket and spigot ends the pipes could be installed with Elastomeric rubber joints at faster rate.

Disadvantages of concrete pipes

- The pipes are heavier and require lifting arrangements especially for large dia. pipes.
- NP2 pipes are not suitable for sewers since three edge bearing strength of these pipes are much lower than NP3 and NP4 pipes.
- Lining with high alumina cement may be required to protect the pipe from corrosion

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5.2.13. Manholes

i. Shape of Manhole

Refer Manual on Sewerage and Sewage Treatment, Ministry of Urban Development New Delhi, December1993, Page No. 74-77, Chapter 4: Sewer Appurtenances

- *RectangularManholes:*
  - Size 900x800mmfordepthupto0.9m
  - Size1200x900mmfordepthbetween0.9to 2.5m.
- *CircularManholes:*
  - Circular manholes are stronger than rectangular and arch type manholes and thus these are preferred over rectangular as well as arch type manholes.
  - The circular manholes are provided for all depths starting from 0.9 m.
  - Circular manholes are straight down in lower portion and slanting in top portion so as to narrow down the top opening equal to internal dia of manhole cover.

Sewer transitions occur wherever conduits of different characteristics are connected. The difference may be flow, area, shape, grade, alignment and conduit material, with a combination of one or all characteristics. Manholes should be located at all such transitions.

ii. Spacing of Manholes

On sewers, which are to be cleaned manually but cannot be entered for cleaning or inspection, the optimum distance between manholes may be 30m but adopted value is 15m due to heavily dense area.

For sewers which are to be cleaned with mechanical devices, the spacing of manholes will depend upon the type of equipment to be used for cleaning sewers. For the diameters less than 910mm, spacing of manholes adopted is 30m to 90m as per site accessibility.

The spacing of manholes above 90m to 150m may be allowed for sewers of diameter 910 to 1520 mm, 150 to 200m may be allowed for 1520mm to 2000mm and which may further be increased upto 300m for sewer of over 2.0 m diameter as per site accessibility.

Circular manholes can be provided for all depths starting from 0.91m for depth below 0.9m, rectangular/square chambers would be adopted. The internal diameter of circular manholes may be kept as shown in Table 7 for varying depths (Ref. 4.2.1.2 of CPHEEO Manual on Sewerage and Sewage Treatment).

Table 7: Diameter Wise Depth for Manholes

Sl. No.	Depth	Diameter of Manhole
1.	Above 0.90 m and upto1.65m	900 mm
2.	Above 1.65 m and upto2.30m	1200mm
3.	Above 2.30 m and upto9.0m	1500mm
4.	Above 9.0 m and upto14m	1800 mm

The size of manhole covers should be such that there should be clear opening of not less than 560mm diameters for manholes exceeding 0.90 m depth (Ref.4.2.1.3 of CPHEEO Manual on Sewerage and Sewage Treatment).

Construction of manholes is preferred with pre-cast RCC manhole with chosen jointing systems or cast-in situ RCC manhole with PE lining of approved thickness except in the channel portions, reinforced concrete bases, rings and cone sections with rubber gaskets between sections. Recent developments for groundwater infiltration elimination involve the use of mastic sealing around the outside of manholes at the joints. However, brick manholes with Cement mortar applied to the inside of manhole is a cost effective way of reducing infiltration in wet soils. These modifications shall result in a significant decrease of infiltration in manholes.

iii. Drop Manhole

When a sewer connects with another sewer, where the difference in level between waterlines (peak flow levels) of main line and the invert level of branch line is more than 600mm or a drop of more than 600 mm is required to be given in the same sewer line and it is uneconomical or impractical to arrange the connection within 600mm, a drop connection shall be provided for which a manhole may be built incorporating a vertical or nearly vertical drop pipe from the higher sewer to the lower one (Ref.4.2.2.4 of CPHEEO Manual on Sewerage and Sewage Treatment).

iv. Junction Manholes

Junction manholes are provided where more than two pipes intersect. These are provided to combine the inflow from two or more pipes with one designated outlet. The diameter of the junction manhole must be large enough so that the distances between adjacent openings have enough strength to resist lateral and vertical loads, as well as stresses caused by handling.

v. Manhole Covers and Frames

The size of the manhole covers should be such that there should be clear opening of not less than 560 mm diameter for manholes exceeding 0.90 m depth. Provision of SFRC manhole covers has been in accordance with as per IS 12592 (latest revision). The cover frame is proposed to be embedded in plain concrete on top of masonry to correct alignment and level with suitable lifting arrangement.

vi. Foot rest-rungs

Footsteps in manhole chambers at every 0.30 m height and 0.30 m width (zig-zag) should be provided. Provision for SFRC footsteps rungs has been considered in project.

vii. Ventilation Shafts

In modern, well designed sewerage system, there is no need to provide ventilation on such elaborate scale considered necessary in the past, especially with the present day policy to not intercepting traps in house connections. The ventilating columns are not necessary where intercepting traps are not provided. It is necessary however, to make provision for the escape of air to take care of the exigencies of full flow and also to keep the sewage as fresh as possible especially in outfall sewers.

5.2.14. House Sewer Connection

To provide the benefit of laid system property connection work is an important for which provision of inspection chamber for house service connections needs to be provided under the project. Provisions of House Sewer Connection Chamber (Inspection Chambers) have been provided on either side of the road to facilitate connection to the system by existing and prospective consumers. HDPE DWC pipe of 110 mm dia is proposed to connect the house chamber to manholes

5.2.15. Trenching for open excavation

The trench width for laying of sewer should be sufficient enough as per norms mentioned in CPHEEO manual with due consideration for bedding.

5.2.16. Shoring

Adequate shoring shall be provided to prevent caving in of trench walls of subsidence of areas adjacent to the trench. In narrow trenches of limited depth, shoring shall be required to be done in accordance to the relevant IS code.

Continuous sheeting shall be provided outside the wall plates to maintain stability of the trench walls. The number and size of the wall plates shall be fixed considering the depth of trench and type of soil. Cross struts shall be fixed in a manner to maintain pressure against the wall plates which in turn shall be kept pressed against the timber sheeting by means of timber wedges or dog spikes.

5.2.17. Pipe Bedding

Bedding of sewers is essential whether the sewer rests on rock surface or soil surface to prevent sagging and cracking of pipe and also to obtain safe supporting strength to the pipe. In a buried sewer, stresses are included by external loads and the stresses due to these loads are of utmost importance for designing of pipe bedding.

As per Clause 3.50.3.7 of CPHEEO manual, Four classes of bedding - A, B, C and D are most commonly used for laying of pipes in trenches:

Class A bedding is concrete cradle - plain concrete with tamped backfill. Class B bedding is compacted granular bedding with compacted backfill.

Class C bedding consists of earth to fit the bottom surface of the conduit. For rock foundations, the conduit is laid on a layer of granular cushion and the sides of the conduit are filled up.

Class D bedding consists of laying the conduit on earth not shaped to fit the bottom of the conduit. In case of rocky soil, the conduit is laid on a shallow granular cushion.

5.2.18. Laying, Lowering & Jointing

All pipes shall be carefully handled and lowered in to the trench by means of proper methods of handling. The pipes shall be handled by flat rubber belts. Socket should face the opposite to the direction of flow. Pipe shall be normally laid so that spigot end enters the socket face. The rubber ring to be used for the jointing of RCC pipes will be of synthetic type.

5.2.19. Jointing DWC Pipe

Each pipe with the rubber ring accurately positioned on the groove shall be pushed well home into the coupler by means of uniformly applied pressure with the aid of a jack or similar appliance. DWCPE plain end pipes with roll on rubber rings shall be used, and the manufacturer's instructions shall be deemed to form a part of this specification. Rubber rings shall be lubricated before making the joint and the lubricant shall only be soft soap water or an approved lubricant supplied by the manufacturer. In case of DWCPE pipe entering or leaving a manhole a flexible joint may be provided at least within 0.60 M from the outer end of the manhole. A drop in water level of not more than 50 mm in one hour shall be permitted, in case of hydraulic test of manhole.

5.2.20. Jointing RCC Pipe

The manufacturing / supplying, laying and jointing of all Reinforced Cement concrete (RCC) pipes shall be done in accordance with clauses of Standard Specifications. The pipes shall be spigot and socket type and jointing of RCC pipes shall be done using rubber gaskets conforming to IS 5382 (ISI Marked). All the pipes shall be manufactured as specified in IS 458 up to latest amendment and laid in trench as per IS 783. All the tests as specified in Standard Specifications in addition to breaking the pipe to check the reinforcement shall be performed by the Contractor at his own cost and in presence of the Engineer or his representative only. The bedding below the pipe line and backfilling shall be provided as per the standard drawing.

5.2.21. Hydraulic Testing

After the work of laying and jointing CI pipes is completed, the pipes line shall be subjected to hydraulic test at work site as per Standard Specifications. The pipe line should be tested within four days time after laying of pipe line.

Each section of sewer shall be tested for water tightness preferably between manholes. To prevent change in alignment and disturbances after the pipes have been laid, it is desirable to backfill the pipes up to the top keeping at least 90cm length of the pipe open at the joints.

The leakage or quantity of water to be supplied to maintain the test pressure during the period of 10 minutes shall not exceed 0.2 litres per mm diameter of pipes per kilometre length per day.

5.2.22. Backfilling

Backfilling of the sewer trench is a very important consideration in sewer construction. The method of backfilling to be used varies with the width of the trench, the character of material excavated, the method of excavation and degree of compaction required. In developed streets, a higher degree of compaction is required to minimize the load while in less important streets, moderate level of compaction may be sufficient.

Backfilling shall be done only after testing of sewer stretches for water tightness at the joints. The refilling shall proceed around and above the pipes. Soft material screened free from stones or hard substances shall be first used and hand pressed under and around the pipes to half their depth. Similar soft material shall be put up to a height of 15 cm above the top of the pipe and this will be moistened with water and well rammed. The remainder of the trench can be filled with hard material in stages, each not exceeding 15 cm. at each stage the filling shall be well rammed, consolidated and completely saturated with water and then only further filling shall be continued.

5.2.23. Removal of Sheeting

Sheeting driven below the spring line of a sewer shall be withdrawn a little at a time as the back-filling progresses. In order to avoid any damage to buildings, cables, gas mains, water mains, sewers, etc., near the excavation or to avoid disturbance to the sewer already laid portions of the sheeting may be left in trenches.

5.2.24. Manhole Construction

It is proposed to construct manholes using brickwork and are jointed at site by special grooves provided during fabrication. The foundation of manholes shall be minimum of 20 cm thick cement concrete of 1:2:4 grade the projection of concrete being 20cm on all sides of the external face of RCC work. The floor of the manhole shall be constructed in cement concrete of 1:2:4 grades.

Concrete half channel pipes of required size and curve shall be laid and embedded in cement concrete base to the same line and fall as the sewer. Both sides of the channel pipes shall be benched up in cement concrete and rendered smooth in 20 mm thick cement mortar and formed to a slope of 1 in 10 to the channel. All round the pipe there shall be a joint of cement mortar 12 mm thick between the pipe and the concrete. The ends of the pipe shall be built in and neatly finished off with cement mortar.

The RCC shaft or the manhole shall be provided on the top with heavy duty air tight DI frame and cover. The manholes shall be provided encapsulated plastic steps and shall be built into the wall of manhole. The distance between the two consecutive steps shall not be more than 30 cm. The top of the manhole shall be flush with the finished road level.

For manholes having difference in the invert levels of incoming and outgoing sewers of 60 cm or more, a vertical drop arrangement comprising of PVC-U pipes with 45 degrees duck foot bend and tee junction clamped to the RCC wall shall be provided.

5.3. Sewage Pumping Station

5.3.1. Pump station Classification

Classification	Pumping capacity	Pump driver HP
Small	< 18 MLD	<30 hp
Medium	18 MLD to 200 MLD	30- 200 hp
Large	> 200 MLD	> 200 hp

From another perspective, small pump stations are served by collector or trunk sewer systems. Medium pump stations are served by trunk or interceptor sewer systems. Large pump stations are served by interceptor sewer systems only.

5.3.2. Factors to be considered in establishing SPS

Classification	Factors
Small	1. Residential area. 2. No significant commercial facilities, hospitals, nursing homes, schools, or correctional institutions within sewer shed.
Medium	1. Large commercial facilities, hospitals, nursing homes, schools, or correctional facilities within sewer shed. 2. Pump station failure would result in overflow to creek or drainage facility not directly tributary to American River, Folsom Lake, or drinking water source.
Large	1. Large commercial facilities, hospitals, nursing homes, schools, or correctional facilities within sewer shed. 2. Pump station failure would result in overflow to American River, Folsom Lake, or drinking water source.

5.3.3. Adopted Design Criteria-Structural Design of WWPS

The pumping stations shall consist of an inlet chamber, coarse screen chamber and a wet well. Non-clog sewage Submersible pumps will be installed in the wet-well. All electrical equipment like transformers, DG set, etc shall be installed at a suitable distance from the wet well. Civil Structure shall be provided for the electrical equipment installations. This room will be ventilated well.

All the civil structures in the pumping stations shall be of RCC Wall Construction having RCC Base Raft Slab and Floor.

For all practical purposes and carrying out structural designing the water table has been considered to be at ground level. The present/ natural ground level has been raised up to road level to prepare FGL and further top of walls is kept 5OOmm above that FGL so as to make the site free from flooding, etc.

The preliminary structural designing using Reynolds's Chart, Moody's Chart and IS 3370 has been carried for the SPS with Wet well having submersible pumps. Thicknesses of the walls and slabs so reached are used. Factor of safety against uplift is considered to be 1.2.

Control Room Building for SPS is single storied building providing space for. LT panel, Store and office etc.

Building is designed as RCC framed structure with filler bricks. The building is analysed and designed as per IS 456, using limit state methodology.

Office or Workshop is considered to be of load bearing construction for small Pumping Stations. All the loads and load combinations are considered as per IS: 875.

5.3.4. Site layout and access for New Sewage Pump Station

The site must be made accessible by vehicles by means of an all-weather access road. The access road shall be constructed from compacted gravel unless otherwise specified. The layout of the pumping station and other features must ensure that the available space for maintenance purposes is maximised.

The following additional factors should be considered when selecting the location of a pumping station:

All materials and equipment are to have minimum 12 months warranty.

- All brackets, access ladders, lifting chains, chemical set anchor bolts, bolts, nuts and washers are to be stainless steel.
- All stainless steel is to be grade 316 or better.
- Mild steel items to be hot dipped galvanised in accordance with A.S. 1650
- Fixing of holding brackets to pump station wall shall be carried out in accordance with manufacturer’s instructions and the relevant Australian Standards.

5.3.5. Wet well

Wet well design shall be as per norms prescribed in CPHEEO manual

5.3.6. Sewage Pumps selection:

i) Non-clog sewage Submersible pumps for all sewage pump (lift) stations (SPS)

ii) Non-clog centrifugal pumps preferably for all higher capacity SPS, like Transfer/Relay stations.

iii) Factory-built sewage pumping station site for road-side lifts stations, if enough space is not available.

Pumps capacity and number of pumps: (Para 9.7 of CPHEEO)

1. The capacity of pump shall be adequate to meet the peak rate of flow with 50% standby. In general, 1 pump of 1 Average flow, 1 of 2 Average flow and third of peak flow capacity to be provided.
2. For larger stations, 5 pumps shall be provided. 2 of ½ Average flow, 2 for 1 Average flow and 1 of Peak flow capacity shall be provided.

5.3.7. Design Head & Electrical equipment

1. Total head of pumping shall be computed as per Para 9.7.5 of CPHEEO.
2. Electrical Equipment as per Para 9-9 of CPHEEO
3. Hydraulic Design Considerations: Hydraulic design considerations include the avoidance of excessive submerged and free-surface vortices, excessive pre-swirl of flow entering the pump, non-uniform spatial distribution of velocity at the impeller eye, excessive variations in velocity and swirl with time, and entrained air or gas bubbles.

5.3.8. Guide Rails

Guide rails are to be fabricated from two number 50mm dia. x 3.2mm thick circular hollow sections internally and externally hot dipped galvanised coated in accordance with AS 1650. Alternatively grade 316 stainless steel tubing of the same dimensions may be used.

Guide Rail Fixing

Guide rail fixing is to be to the pump well access entrance, pump well floor and to have stainless steel anti-spread brackets located at not greater than 2 metre centres.

5.3.9. Lifting Chain

The lifting chain is to be Stainless Steel capable of lifting 1.5 times the weight of the pump weight without exceeding yield stress. Chain is to be attached to pump lifting hooks by means of a stainless steel shackle meeting A.S 2741 Standards. The other end of chain shall be placed on a Stainless Steel chain hook at pump well entrance in similar position as pump guide rail holding bracket.

5.3.10. Gantry with pulley block

The wet well shall be provided with gantry girder with travelling pulley block of capacity 1.5 times the capacity of weight of largest pump with span equal to the wet well diameter and enough lifting height.

5.3.11. Pump ID Plate

An engraved ID plate will be fixed to inside of the pump opening in the well identifying the pump number below, which coincides with the pump control and SCADA system, such as “PUMP 1”.

5.3.12. Pumping station wet-well isolating valve

Knife gate valves shall be used and shall confirm to the following criteria

- Knife gate valve to be Bi-directional with non- rising stem, Grade 316 SS.
- Component and Grade 316 S.S. extension spindle extension spindle to be supported by Grade 316 SS support brackets at suitable spacing. Valve to be supplied complete with valve key cover box and all nuts, bolts and washers and gaskets for insertion between flanges, drilled off centre; and,
- The mounting flange must be ductile iron or fabricated from grade 316L stainless steel.

5.3.13. Pump Station Controls

Each pump is to be fitted with the following manual switch configuration.

On and Off

The pump will operate independently of automatic control system from the station controller. A Local / Remote Duty selector switch shall be installed to provide a separation of station operation. This switch shall be arranged to provide Control Circuit Functions for:

Auto / Local Control

Primary Station Auto Local control operation shall be set up in accordance with pre-set levels; Pump control details, such as operating levels shall be pre-programmed into the MNN controller to provide for Duty / Standby operation of the pumps. A Pump duty selector switch shall be installed to provide for duty 1 - 2 or 2 - 1 operating mode.

Auto Cycling of Pump units is not required for Local Auto Running. Emergency Local Control Auto Running shall be initiated by means of a High Level Float. Such running and control shall be confined to LOCAL AUTO run.

The emergency high level float control shall remain DISABLED during:-

1. pump OFF isolation, and
2. telemetry REMOTE control selection

Pump Control	Level/Setting
duty cut-in level	set at 150mm below the incoming sewer invert level
cut-out level	50mm above pump cavitation level
low level alarm	at the cavitation level of the pump set
standby cut-in level	set at 150mm above the duty cut-in level
high level alarm / float	set at 300mm above standby cut-in level
emergency level alarm	set at 500mm above standby cut-in level

Pump control is to be set for not greater than 6 hours detention period.

The pump controller is to switch off pump(s) under the following conditions:

Low water level;

1. Thermostatic overload is tripped;
2. Where pump is manually selected to off "position".

5.3.14. Storage consideration

Wastewater storage for emergency purpose is appropriate as a means to mitigate pump station failures. Within the District, these failures have occurred due to the following:

(1) Communication failures within the SCADA system

(2) Power failure

(3) Instrumentation (level measuring components, PLC, OIPs) malfunctions

(4) Electrical component failure

(5) Mechanical equipment failure (check valves, pump volutes)

To avoid or mitigate these failure modes, a number of preventative measures can be implemented. These include:

(1) Emergency storage

(2) SCADA system design that allows for continued pump station operation even when a communication failure occurs

(3) Installation of emergency power generation equipment

(4) Furnishing of back-up instrumentation systems

(5) Avoiding single points of failure in electrical distribution systems

(6) Improving mechanical reliability through additional redundant equipment

5.3.15. Yard Lighting

Yard lighting shall be provided for the pumping station as per norms prescribed as per relevant IS.

5.3.16. Drinking water

Drinking water provision shall be made in all sewage pumping stations from the Municipal water supply.

5.3.17. Surge Issues

Surge analysis, or hydraulic transient analysis, for the pump station, force main, and appurtenances (air release valves) should be performed, if one of the following conditions exists:

(a) Pumping total dynamic head (TDH) is greater than 12 m and flow exceeds 2000 lpm.

(b) Pipelines have high points or “knees”. Power failures can cause a partial vacuum at the knee and can result in column separation (with only water vapour in the pipe at the knee).

Surge mitigation can be accomplished by the following control strategies:

(a) Reroute force mains to avoid knees.

(b) Use pump control valves that open and close gradually.

(c) Increase rotating moment of inertia by adding a flywheel.

(d) Use engine drives on some pumps so the entire system cannot fail at once.

(e) VFDs guard against continual pounding at start-ups and shut down but do not protect from power failure, if VFD system is used.

(f) Add vacuum relief valves at critical points.

(g) Hydropneumatic tanks. If specified, hydropneumatic tanks should be designed, fabricated, and tested in accordance with the ASME Code for Unfired Pressure Vessels, and should be equipped with compressed air system controls to maintain air-to-water ratio.

(h) Air-vacuum valves

(4) Piping Characteristics: Suction piping diameter to the pump should be at least one size larger than the pump inlet diameter.

g. Pipeline Features and Appurtenances: In terms of changes in direction, multiple 45 degree or 22.5 degree bends should be used in lieu of short radius 90 degree fittings. Force mains should be designed so that the pipeline is always full and that no point in the vertical alignment is located above the energy grade line. The number of low and high points should be kept to a minimum because high points can lead to air traps and sulphide corrosion. If high and low points are unavoidable, air relief/vacuum and blow off valves should be installed respectively at high and low points. If possible, blow off valves should discharge to a sanitary sewer manhole. Cleanout or flushing attachments to facilitate maintenance and provisions to prevent vandalism should be provided. Valve location versus the pipe cross section should consider the potential for grease accumulation. Because air relief valves require frequent maintenance, the valves should be located outside of the travel way as much as possible. The valves should be identified with a pump station diameter, diameter of force main, and location of the force main.

At the pump station a 50 mm ball valve should be provided on the top of the pump volute discharge to allow removal of air after servicing and prior to placing dry well pumps back in service. The vent line should be plumbed to discharge to the wet well or sump pump.

To avoid shearing force mains due to differential settlement, flex couplings should be used on pipelines between the pump station structures and vaults. Thrust forces in force mains should be mitigated through joints that are restrained or anchored to prevent excessive movement and joint separation. Provisions for launching and retrieving cleaning pigs should be considered in the design for pipe diameters 600 mm and smaller. Pig launching facilities may be as simple as a pipe wye or more elaborate, with a special launch chamber, bypass piping, and valves. In either case, gauges should be attached to monitor pressure. Retrieval facilities may also be elaborate or simple. Elaborate retrieval devices are usually mirror images of the launch device. Simpler retrieval methods can include baskets, traps, or screens placed in the receiving manhole.

Dual force mains can be considered for phasing purposes along with obtaining proper velocities under all flow conditions. Dual mains also make it possible to empty a force main for maintenance or repair purposes. Provisions for pipeline draining and flushing should be included in the force main design. Dual force mains may require automated control valves linked to pumping equipment operation.

For force main discharges, the force main should enter the receiving manhole with its centreline horizontal and an invert elevation below the gravity line to ensure a smooth transition of flow to the gravity flow section. In no case, should the force main enter the gravity system at a point more than one foot above the flow line of the receiving manhole. The design should minimize turbulence at the point of discharge and it should keep the force main completely full at all times. Consideration shall be given to the use of inert materials or protective coatings for the receiving manhole to prevent deterioration from hydrogen sulphide or other chemicals. These conditions are especially likely to be present if the force main is long (more than four hours of detention time).

5.3.18. Sewage Treatment Plant-Design Norms & Standards

For better hygienic conditions in the town Sewage & sullage catered from habitation is required to be treated as per the CPHEEO norms. Hence provision for Sewage Treatment Plant (STP) has been proposed in the scope of work.

Table 8: Expected Raw Sewage Characteristics

Sl.No.	PARAMETER	UNIT	RAWSEWAGE
1	pH	mg/l	6.5 - 7.5
2	BOD 5 @ 20o C	mg/l	300
3	COD	mg/l	600

Sl.No.	PARAMETER	UNIT	RAWSEWAGE
4	TSS	mg/l	600
5	TKN	mg/l	55
6	TN	mg/l	--
7	TP	mg/l	6

5.3.19. Sewage Treatment Technologies

Several alternative technologies are available for the treatment of sewage for making it suitable for disposal in environmentally safe manner or for making it suitable for reuse purpose. Some of the technologies evaluated for Chennai are listed below

i. Conventional Activated Sludge Process
ii. Cyclic Activated Sludge treatment technology (Sequential Batch Reactors)
iii. Extended Aeration Method
iv. Up flow Anaerobic Sludge Blanket Reactor
v. Aerated Lagoons
vi. Facultative lagoons
vii. Anaerobic Ponds followed by facultative Stabilization Ponds
viii. Moving Bed Bio Reactor Process
ix. Membrane Bio Reactor

Choice of treatment technology is governed by factors like, ultimate disposal method, land availability, capital & operating cost, availability of skill for O & M, etc. In order to make appropriate selection a study of the various aspects of the alternative technologies are to be studied along with requirement of the project. This subject is discussed, in details, in subsequent sections

5.3.20. Selection of Disposal Methods

One primary thing that affects the selection of treatment technology is the mode of disposal to be adopted. Quality of treated sewage is required to be fixed as per the requirement of the selected mode of disposal. In case of Chennai, following disposal modes can be considered.

- Disposal into inland surface water
- Disposal on land for irrigation
- Disposal into Sea
- Reclamation for reuse

Reclamation for reuse is good for water scarcity areas and where there is potential and infrastructure available for reuse. Considering the water Scarcity in the Chennai, this mode of disposal can be considered as one of priority.

For the above disposal method, required Treated Water Quality as prescribed by Ministry of Environment And Forest, Government of India (MOEF) is given below:

Table 9: Treated Water Quality Requirement

Parameters	Conc. Value in the raw sewage	Quality Required for Discharge into inland surface water	Quality required for discharge on land for irrigation	Quality Required for discharge into Marine and Coastal area	Quality required for Reuse
pH		5.5 to 9.0	5.5 to 9.0	5.5 to 9	6.5 to 7.5
Biological Oxygen Demand (BOD_5 at 20°C) mg/l	300 to 400	30	100	100	Below 10
Chemical Oxygen Demand (COD) mg/l	600 to 700	250	-	250	Below 50
Total Dissolved Solids mg/l		2100	2100	2100	Below 1000
Suspended Solidsmg/l	600 to 800	30	200	100	Below 10
Total Kjeldal Nitrogen as Nmg/l	50 to 60	100	-	100	Below 5
Free Ammonia as Nmg/l	25 to 30	50	-	50	Below 5
Nitrate Nitrogen as Nmg/l		10		20	
Soluble Phosphates as Pmg/l	27	5	-	-	Below 0.5
Oil and Greasemg/l	150 to 200	1	1	20	Nil
Gritmg/l	80 to 120	1	1	-	Nil
Residual Chlorine as Clmg/l		1			1

In addition following NRCD guideline in respect of Faecal Coliform is required to fulfilled

Table 10: Discharging Process

Parameters	Discharge on to Land		Discharging into Water	
	Desirable	Maximum Permissible	Desirable	Maximum Permissible
Faecal Coli form	1000	10000	1000	10000

Notes:

i. Raw Sewage Quality is calculated based on standard norms. Actual value to be considered for design will be based on actual analysis.

ii. Only Main parameters listed.

iii. Treated water Quality for reuse is given for general use in non-potable application like flushing toilets, car washings, watering sports grounds and recreational areas, for reuse in particular industrial application quality required to be modified as per the propose application.

Treatment technologies that can produce effluent of above mentioned quality will be suitable for Chennai from disposal point of view.

5.3.21. Selection of Treatment Technology

In primary scanning, following treatment methods are evaluated for implementation in Agra

1. Conventional Activated Sludge Process
2. Cyclic Activated Sludge treatment technology (Sequential Batch Reactors)
3. Extended Aeration Method
4. Up flow Anaerobic Sludge Blanket Reactor
5. Aerated Lagoons
6. Facultative lagoons
7. Anaerobic Ponds followed by facultative Stabilization Ponds

Method listed at Sr. No 1, 2 and 3 above will generate water suitable for disposal into inland surface water and thus can be adopted for plants where treated water is to be discharged in to canal or river. Method listed at Sr. No. 4 to 7 will generate treated effluent suitable for disposal on land for irrigation.

If Reclamation for reuse is to be adopted, methods listed at Sr. No 1, 2 and 3 above can be used by providing additional units for tertiary treatment.

5.3.22. Design Norms used for evaluation module

Primary treatment for all above methods is common and will consist of screening and de gritting. Configuration of secondary treatment varies in all above methods. Capital Cost, Treatment efficiencies, land and power requirement are also different in different methods.

Designed norms are selected as recommended by CPHEEO Manual. 2^{nd} Edition of CPHEEO manual is referred for selection of design norms.

Design Norms for major units are followed are given here below.

Table 11: Design Norms for Course Screen

Sl. No.	Process Unit and design Parameter	Recommended Norms	Value used	Reference
A	**Screen Channel**			
1	Velocity in approach channel at low flow	> 0.30 m/sec	0.6 m/sec	As per CPHEEO manual, page 202
2	Velocity at screen at peak flow	0.6 to 1.2 m/sec	0.9 m/sec	
3	Minimum Velocity	Not below 0.3 m/sec	Not below 0.3m/sec	
B	**Coarse Screens**			
1	Nos.	2 (Duplicate)	2	As per CPHEEO manual, page 157
2	Clear opening & Type	40-50 mm Manual cleaning 25 mm- Mechanical cleaning	20 mm Coarse screen mechanically cleaned	

Table 12: Design Norms for Raw sewage Pumping Station

Sl. No.	Process Unit and design Parameter	Recommended Norms	Value used	Reference
A	**Wet Well**			
1	Design Period for civil work	Ultimate	Ultimate	CPHEEO Manual page 157
2	Hydraulic detention time	Maximum 30 minute at average flow rate	30 min	
B	Pumps			
1	Type	Motor Submersible Type		As per CPHEEO manual, page 157
2	Design Period	Intermediate	Intermediate	
3	Capacity	Operation time of minimum duty pump not below 5 min. Combination of pumps should be able to take care of all flow conditions	Same	

Table 13: Design Norms for Screen Channel

Sl. No.	Process Unit and design Parameter	Recommended Norms	Value used	Reference
A	**Screen Channel**			
1	Velocity in approach channel at avg. flow	0.6 to 1.2 m/sec	0.6 m/sec	As per CPHEEO manual, page 202
2	Velocity at screen at peak flow	0.6 to 1.2 m/sec	0.9 m/sec	
3	Minimum Velocity	Not below0.3 m/sec	Not below 0.3m/sec	
B	**Screens**			
1	Clear opening	20 mm	20 mm	As per CPHEEO manual, page 201
2	Type		Main screen mechanically cleaned Bypass screen manually cleaned	

Table 14: Design Norms for De-Gritting Tanks

Sl. No.	Process Unit and design Parameter	Recommended Norms	Value used	Reference
1	HRT	60 sec	60 sec	As per CPHEEO manual, page 209 and 208
2	Surface Loading Rate	946 m/day	946 m/d	
3	Horizontal Velocity Velocity	0.15 to 0.3 m /sec	0.3 m /sec	
4	Control device	Weir		

Table 15: Design Norms for Flow Splitter

Sl. No.	Process Unit and design Parameter	Recommended Norms	Value used	Reference
1	HRT in inlet chamber	60 sec	60 sec	
2	Velocity at outlets	0.8 m /sec at peak	0.8 m /sec at peak	

Table 16: Design Norms for Primary and Secondary Settling Tanks

Sl. No.	Process Unit and design Parameter	Recommended Norms	Value used	Reference
A	**Primary Settling Tank**			
1	Surface Loading Rate	Avg. 35 to 50 m/d Peak 80 to 120 m/d	30 - 75	CPHEEO Manual page 216
2	HRT	2 to 2. 5 hours	2.4 Hours	
3	Depth	2.5 to 3.5 m	3.0 m	
B	**Secondary Settling Tank (FOR CASP)**			

Sl. No.	Process Unit and design Parameter	Recommended Norms	Value used	Reference
1	Surface Loading Rate	Avg. 15 to 35 m/d Peak 40 to 50 m/d	20 - 45	CPHEEO Manual page 216
2	HRT	1.5 to 2.0 hours	2.0 Hours	
3	Depth	3.5 to 4.5 m	3.0 m	
C	**Secondary Settling Tank (FOR Extended Aeration)**			
1	Surface Loading Rate	Avg. 8 to 15 m/d Peak 25 to 35 m/d	15 - 35	CPHEEO Manual page 216
2	HRT	1.5 to 2.0 hours	2.0 Hours	
3	Depth	3.5 to 4.5 m	3.0 m	

Table 17: Design Norms for Aeration Tank

Sl. No.	Process Unit and design Parameter	Recommended Norms	Value used	Reference
A	**For Conventional ASP**			
1	MLSS	3000 to 4000 mg/l	4000 mg/l	
2	MLVSS/MLSS	0.8	0.8	
3	F/M	0.3 to 0.5	0.19	
4	HRT	4 to 5 Hours	13.72 Hours	CPHEEO Manual
5	Mean Cell Residence Time	5 to 8 days	10 days	
6	Recirculation Ratio	0.25 to 0.8	1	
7	Oxygen Supply Rate	0.8 to 1.0 kg /kg of BOD removed	1kg/kg of BOD removed	
8	Volumetric Loading	0.6 kg/m^3	0.6 kg/m^3	Metcalf & Eddy
B	**For Extended Aeration**			
1	MLSS	3000 to 5000 mg/l	5000 mg/l	
2	MLVSS/MLSS	0.6	0.6	
3	F/M	0.1 to 0.18	0.13	
4	HRT	12 to 24 Hours	31.67 Hours	CPHEEO Manual
5	Mean Cell Residence Time	10 to 25 days	26 days	
6	Recirculation Ratio	0.5 to 1.0	1	
7	Oxygen Supply Rate	0.8 to 1.2 kg /kg of BOD removed	1.2 kg/kg BOD removed	
8	Volumetric Loading	0.4 kg/m^3	0.4 kg/m^3	Metcalf & Eddy

Table 18: Design Norms for Aerated and Facultative Lagoon

Sl. No.	Process Unit and design Parameter	Recommended Norms	Value used	Reference
A	For Fully Aerobic Aerated Lagoon			CPHEEO Manual
1	SS in unit	150 to 350 mg/l	200 mg/l	
2	VSS/SS	0.8	0.8	
3	Depth	2.5 to 4.0	3	
4	HRT	2 to 3 days	8 days	
5	Power level	2.75 to 6 watts/m^3	4 Watts/m^3	
B	**For Facultative Lagoon**			
1	SS in unit	40 to 150 mg/l	100 mg/l	CPHEEO Manual
2	VSS/SS	0.6	0.6	
3	Depth	2.5 to 5.0	0.19	
4	HRT	3 to 5 days	7 days	
5	Power level	0.75 watts/m^3	0.75 watts/m^3	

Table 19: Design Norms for UASB

Sl. No.	Process Unit and design Parameter	Recommended Norms
A	Reactor	
1	Hyd. Ret. Time	6 to 10 Hrs
2	COD Loading Rate	1 to 2 kg/m^3.d
3	Velocity	0.6 to 1.0 m/hour
4	No of inlets	1 / 2 m^2
B	Settler	
1	Hyd. Ret. Time	40 to 150 mg/l
2	Surface Loading	1 to 1.25 m/hour
3	Depth	2.0 m to 3.0 m

In Cyclic Activated sludge process (SBR), all steps of secondary treatment are carried out in one tank in cyclic fashion. Sequence and duration of Treatment cycles are pre-engineered. Plant operation is controlled by PLC. Cyclic activated sludge process is proprietary. Design norms for the same are not available in CPHEEO manual. Hence Vendors data have been used for this technology.

Project Area	Projected Population in Nos.			Sewage Generation @ 80% in MLD		
	2020	2035	2050	2020	2035	2050
ABD	106690	155168	226422	12.80	18.62	27.17
Tajganj Sewerage Zone	257960	373706	541534	25.99	37.62	54.87

6. PROPOSED SEWERAGE SYSTEM

6.1. Prelude

This Chapter discusses the concepts adopted in formulating a Comprehensive Underground Sewerage Scheme for Agra Corporation. Agra UGSS was formulated to the ABD area with total capacity of sewage generation during 2050 is about 46.60 MLD ABD area has 4existing sewerage zone and one proposed sewerage zone. These existing zones are partly contributing to the project area (ABD). The sewage generates from each zone is being collected at the intermediate sewage pumping station (IPS). The sewage collected from the IPS is collected at master pumping station (MPS) and further entire sewage is being collected and treated in Sewage Treatment Plant (STP) located at Dhandupura and proposed STP near Garhi village. The designed capacity of STP for 2035 is 18Mld.

6.2. Concept Plan

6.2.1. Sewage Collection System Concepts

The following concepts have been followed in formulating the Sewage Collection System.

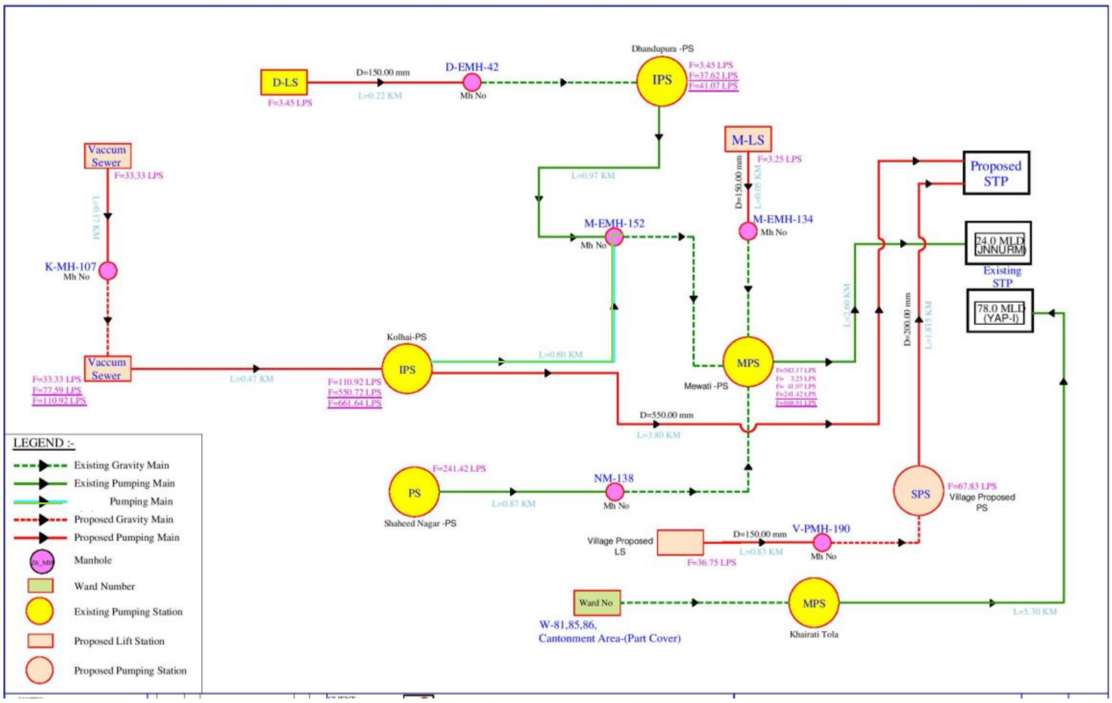
- ❖ Keep the sanitary sewers strictly separate from the storm water drains. All existing storm water connections to existing sewers whether from buildings, house-yards or from open areas like roads shall be plugged as such connections lead to overflow from the sewers on to the roads during rains and also as they cause clogging of the sewers by the silt load carried in with the storm water. No fresh storm water connection to sewers shall be permitted.
- ❖ Make appropriate allowance for groundwater infiltration into sewers.
- ❖ Stop the present practice of letting street sewers to discharge their raw sewage into storm water drains and waterways. Intercepting sewers shall be provided to intercept such sewers and convey their flows to the respective STPs for treatment before disposal.
- ❖ In project Areas which are partially sewered already:
  - (a) Provide sewers in all unsewered streets. The new sewers to be designed for ultimate flows i.e., 2050 flows considering project period as 2020 – 2050.
  - (b) Provide sub-main sewers, main sewers and trunk sewers to intercept the existing and proposed street sewers and convey their sewage to final pumping stations for being pumped to sewage treatment plants.
  - (c) Check the theoretical hydraulic adequacy of existing system with additions as at (a) and (b) to meet 2035 requirements and identify the reaches which are adequate and those which are inadequate. Replace the reaches which are inadequate with sizes suited for 2050 flows. (Adequacy criteria shall be velocity for 2020 peak flow not less than 0.6 m/s and depth of flow for 2035 peak flow not greater than 0.8 D).

(d) Evaluate the performance of sewers which are theoretically adequate for 2035 flows and decide the reaches where the sewers will require repairs/replacement.

(e) Check the theoretical hydraulic adequacy of the system upgraded as at (c) above to carry 2050 flows. (Adequacy criteria shall be velocity of 2020 flows not less than 0.6m/s and depth of flow in 2050 not to exceed 0.8D) Replace the reaches which are inadequate for 2050 flows with larger sizes to be taken up in 2035.

- ❖ Ground slope as available shall be exploited to minimize the depths of sewers. The depth shall be generally restricted to 6 m maximum.
- ❖ Select sewer alignments as will involve minimum number of crossings of physical barriers such as ground humps, nallahs, major roads, railway lines, etc.
- ❖ Design the sewerage system so as to minimize the number of sewage pumping stations.

Figure 4: Flow diagram for Existing and Proposed sewerage system



6.2.2. Sewage lifting station and pumping stations

The following concepts have been adopted for planning the lifting and pumping stations.

(i) Lifting stations are proposed wherever invert level of proposed skewered area not feasible to connect with existing manhole due to difference in invert levels and to reduce the depth of sewers in newly proposed area to maximum of 6m

(ii) The lift stations are connected to existing nearby manhole to carry the flow to zonal pumping stations by gravity

(iii) Lifting stations are to be provided wherever disconnectivity to downstream sewer are observed
(iv) The lifting stations shall be designed to accommodate pumping system with all electrical and mechanical works and pumping main to nearby feasible manholes
(v) The lift stations are with RCC well of 3m inner diameter with detention time of 5 to 10 minutes of peak flow
(vi) Submericible pumpsets capable of pumping lean flow and peak flow with power backup to be provided
(vii) Necessary protection from storm water entry during heavy flood is to be ensured

6.2.3. Sewage Treatment Plant (STP) Design Concept

STP is not propsoed in this DPR in general the following concepts have been adopted for planning the sewage treatment facilities.

a. Fix the location of the STP at the outskirts of the city to minimize nuisances to the public.
b. Examine reuse potential for the treated effluent.
c. Irrespective of the quality requirements for any reuse, provide a certain minimum treatment for the sewage as will permit its disposal into waterways when full reuse is not possible or when there is interruption of reuse.
d. Select sewage treatment process based on technical and economic comparisons of feasible alternatives.
e. Consider the feasibilities of utilizing sludge gas for power generation.

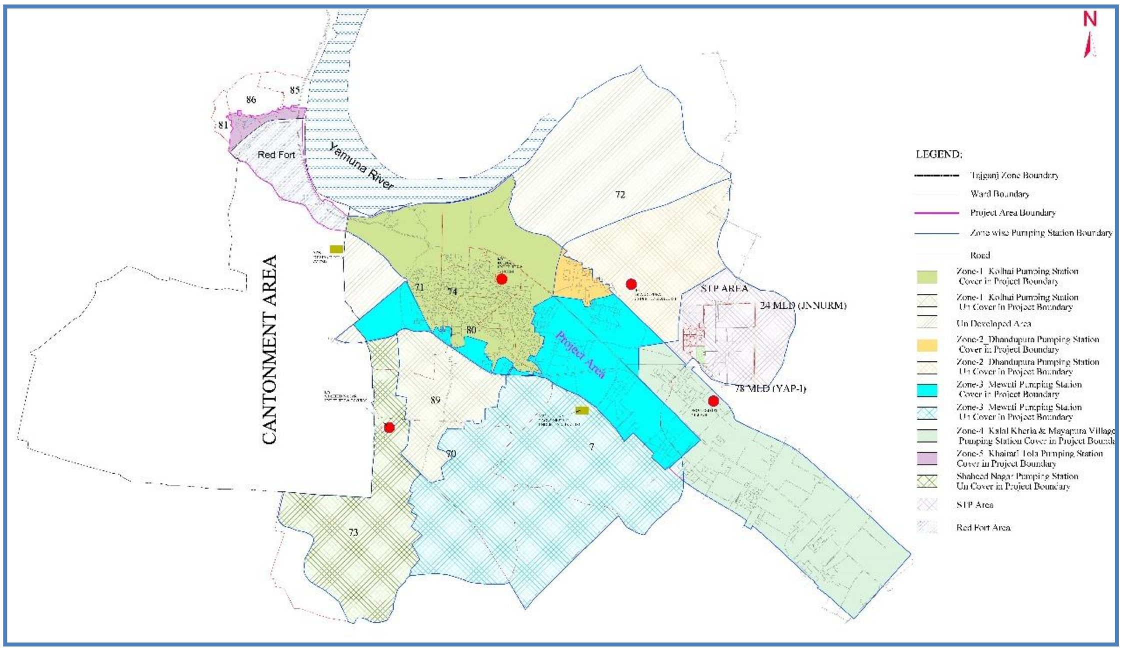
6.2.4. Sewage Flows for Different Horizon Years

As per CPHEEO Sewerage Manual, 80% of the water may be expected to reach the sewers unless there is data available to the contrary. In Agra, it is proposed to supply the water at the rate of 150 LPCD. The expected flow of sewage be 120 LPCD.

6.2.5. Proposed Sewerage System – ABD Area

Existing Sewer zones of Kolhai (P), Nagla Mehwati(P), Dhandupura(P) and Khairati Tola (P) along with proposed proposed uncovered area in Kalalkheria and Mayapura Villages form the ABD area. The zone wise coverage area is shown in the figure below.

Figure 5: zone wise ward area covered in project area



6.2.6. Zoning of existing and proposed sewerage system

Zone wise sewage generation for different horizon years are provided in the Table 20.below:

Table 20: Zone Wise Sewage Generation for different Horizon Years

Sl. No	Ward No.	Total Area (Hect)	Project area (Hect)	% of coverage	Population (Nos.)			Sewage Generation (MLD)		
					2020	2035	2050	2020	2035	2050
1	Ward -7	353.26	165.69	47%	11958	17275	25187	1.43	2.07	3.02
2	Ward -71	96.44	61.04	63%	14269	20759	30293	1.71	2.49	3.64
3	Ward -72	660.46	183.52	28%	3216	4632	6751	0.39	0.56	0.81
4	Ward -74	29.57	29.57	100%	32359	47132	68788	3.88	5.66	8.25
5	Ward - 80	66.02	66.02	100%	28803	41887	61121	3.46	5.03	7.33
6	Ward - 81	17.24	8.63	50%	3735	5453	7960	0.45	0.65	0.96
7	Ward - 85	20.80	4.14	20%	3680	5372	7843	0.44	0.64	0.94
8	Ward - 86	25.12	3.00	12%	1842	2689	3926	0.22	0.32	0.47
9	Kalal Kheria & Mayapura (Vill) -(F)	315.78	315.78	100%	6828	9969	14553	0.82	1.20	1.75
	Total	**1584.69**	**837.38**		**106690**	**155168**	**226422**	**12.8**	**18.6**	**27.2**

6.2.7. Additional Sewers in the Existing ABD Zones

Based on the data received (from the as constructed details) and subsequent discussions with Agra official, missing links in the existing systems were identified and demarcated in the project area network drawing of existing sewer network. These missing links are designed and integrated with the existing network by gravity or providing lifting stations. Details of proposed sewer lines in the unsewered areas of Existing Zones are tabulated below.

Table 21: Details of Proposed sewer lines in the unsewered areas of Existing Zones

Pipe and Manhole Table

Material	Dia in mm	Length of Sewer Lines Proposed for different Zones in m					
		Kolhai	Dhandupura	Mewati	Central	Mayapur & Kalakheria	Total
HDPE DWC	150	7420	1541	5710	386	26063	41270
	200	3752	223	3451	1220	4522	13368
	250	-	-	-	398	75	723
	300	-	-	265	-	355	920
RCC NP3	150	127	-	98	-	897	1272
	200	234	119	1307	-	3725	5585
	250	-	-	-	-	319	569
	300	-	-	-	-	430	730
	350	-	-	1830	-	788	2968
	400	-	-	-	-	307	707
Total		**11533**	**1883**	**12661**	**2004**	**37481**	**69112**
No of Chambers		**489**	**56**	**37**	**0**	**0**	**582**
No of Manholes		**208**	**50**	**439**	**82**	**1405**	**2184**

ABD area having very narrow streets in zone Kolhai in Taj Ganj area. Wherever road width having less than 2m, feasibility for constructing manholes is limited. Hence these streets are proposed with inner chambers of size 0.90 x 0.60 m at 10m interval to connect the house sewers and to ensure 100% coverage in sewer system.

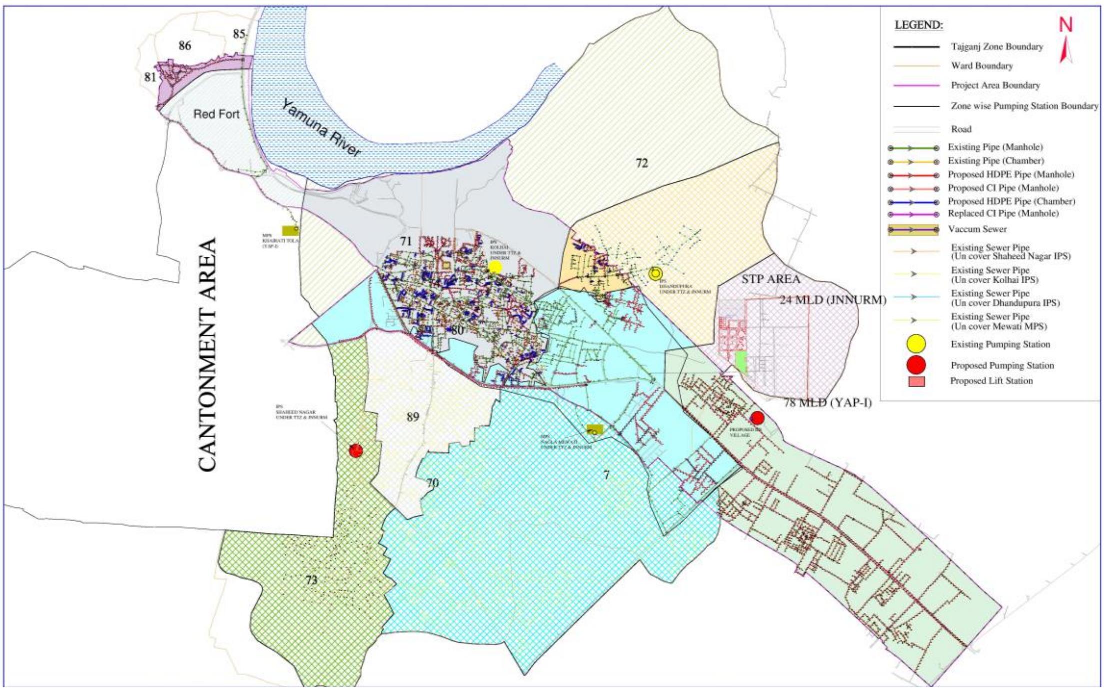


Figure 6: Proposed Missing Links in the Existing Sewer Zones

6.2.8. Zone -Kolhai

6.2.8.1. Sewer Collection system

Kolhai pumping station covers majority of project area. The uncovered areas are identified and proposed in the Kolhai zone. The proposed sewer network is connected to existing manholes wherever feasible. Wherever invert level of proposed sewer is lower than connecting manhole lift stations are proposed. About 10.94 Kms of new sewer lines are proposed in Kolhai collection zone. The details of the proposed sewer network and connecting manhole details are tabulated below.

Table 22: Abstract of proposed sewer network in Kolhai

Material	Sewer depth/dia	150	200	Total
HDPE DWC	1	3668.21	1012.97	4681.18
	1.5	2553.02	1489.19	4042.21
	2	659.91	521.11	1181.02
	2.5	372.88	419.21	792.09
	3	109.6	127.96	237.56
	3.5	56.81	181.59	238.4
RCC	3.5	10.48	35.74	46.22
	4	84.66	53.59	138.25
	4.5	31.35	10.15	41.5
	5	0	56.07	56.07
	5.5	0	0	0
	6	0	51.79	51.79

Material	Sewer depth/dia	150	200	Total
	6.5	0	0	0
	7	0	26.99	26.99
Total		**7546.92**	**3986.36**	**11533.28**

Table 23: Zone Kolhai- Details of Proposed sewer lines and connecting manhole details

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	**Elevation (Ground) (m)**	**Elevation (Invert) (m)**	**Flow (Total Out) (L/s)**	**Dia of Pipe in mm**	**Existing Connecting Manhole Number**	**Existing Connecting I.L. (m)**	**Existing Connecting Dia in mm**
K-OF-1	157.23	156.12	0.55	200	KE-538	155.87	250
K-OF-2	163.99	162.93	0.05	150	KH-C-245	161.99	200
K-OF-3	162.4	160.17	0.25	150	KE-584	157.92	250
K-OF-4	159.34	158.59	0.42	150	KE-293	158.11	250
K-OF-5	166.38	164.92	0.04	150	KE-495	164.3	250
K-OF-6	165.82	164.37	0.04	150	KE-496	162.38	250
K-OF-7	163.4	162.29	0.25	200	KE-499	161.52	250
K-OF-8	163.41	162.3	1.07	200	KE-142	160.6	250
K-OF-9	165.58	164.47	0.93	200	KE-167	163.45	250
K-OF-10	164.37	163.15	0.23	150	KH-C-157	161.79	200
K-OF-11	168.4	166.03	0.32	200	KE-159	165.7	250
K-OF-12	163	161.94	0.16	150	KE-498	161.73	250
K-OF-13	161.03	159.96	0.04	150	KE-73	159.45	250
K-OF-14	169	167.03	0.06	150	KH-C-49	166.8	200

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	Elevation (Ground) (m)	Elevation (Invert) (m)	Flow (Total Out) (L/s)	Dia of Pipe in mm	Existing Connecting Manhole Number	Existing Connecting I.L. (m)	Existing Connecting Dia in mm
K-OF-15	165.15	164.09	0.04	150	KE-377	161.43	250
K-OF-16	164.62	163.2	0.03	150	KE-516	161.65	250
K-OF-17	162.82	161.71	0.03	150	KE-517	160.51	250
K-OF-18	173.38	171.77	0.12	150	KH-C-294	167.5	200
K-OF-19	171.44	169.99	0.21	150	KE-391	164.25	250
K-OF-20	168.84	167.78	0.17	150	KE-435	165.8	250
K-OF-21	165.02	163.86	0.02	150	KE-350	163.79	250
K-OF-22	165.57	164.4	0.03	150	KE-345	163.85	250
K-OF-23	164.54	162.94	0.07	150	KE-370	162.71	250
K-OF-24	166.96	164.3	0.16	150	KE-321	164.11	250
K-OF-25	165.38	164.32	0.71	150	KE-426	163.02	250
K-OF-26	165.16	164.1	0.39	150	KE-421	163.83	250
K-OF-27	166.5	164.82	0.33	150	KE-406	164.29	250
K-OF-28	160.82	159.71	0.25	200	KE-121	158.73	250
K-OF-29	162.87	161.38	0.13	150	KE-531	160.62	250
K-OF-30	163.39	162.15	0.47	200	KE-691	157.36	300
K-OF-31	163.02	160.89	1.65	200	KE-692	157.26	300
K-OF-32	164.51	159.55	2.12	200	KE-686	157.94	300
K-OF-33	164.28	163.06	0.17	150	KE-685	158.06	250

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	Elevation (Ground) (m)	Elevation (Invert) (m)	Flow (Total Out) (L/s)	Dia of Pipe in mm	Existing Connecting Manhole Number	Existing Connecting I.L. (m)	Existing Connecting Dia in mm
K-OF-34	164.39	161.81	1.61	200	KE-683	160.77	250
K-OF-35	164.91	163.18	0.02	150	KE-632	161.63	250
K-OF-36	166.11	165.05	0.5	150	KE-9	164.85	250
K-OF-37	165.98	164.91	0.42	150	KE-9	164.85	250
K-OF-38	165.49	163.96	0.58	200	KE-215	161.03	250
K-OF-39	168.07	166.74	0.32	200	KH-C-113	164.89	200
K-OF-40	167.17	166.11	0.16	150	KE-137	165.73	250
K-OF-41	167.47	166.07	0.36	150	KE-136	165.75	250
K-OF-42	167.06	166	0.74	150	KE-135	165.83	250
K-OF-43	164.95	163.88	0.67	150	KE-673	161.01	250
K-OF-44	166.73	165.1	0.09	150	KE-611	164.9	250
K-OF-45	167.11	166.05	0.16	150	KE-601	165.73	250
K-OF-46	166.8	165.74	0.12	150	KE-722	165.36	250
K-OF-47	167.99	166.93	0.24	150	KE-617	165.68	250
K-OF-48	167.28	166.21	0.12	150	KE-620	165.53	250
K-OF-49	168.4	167.25	0.11	150	KH-C-133	167.15	200
K-OF-50	164.23	163.06	0.27	200	KE-170	162.63	250
K-OF-51	164.86	162.93	0.3	200	KE-721	162.67	250
K-OF-52	167.02	165.88	0.35	150	KE-203	165.56	250

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	Elevation (Ground) (m)	Elevation (Invert) (m)	Flow (Total Out) (L/s)	Dia of Pipe in mm	Existing Connecting Manhole Number	Existing Connecting I.L. (m)	Existing Connecting Dia in mm
K-OF-53	166.87	165.67	0.09	150	KE-223	165.3	250
K-OF-54	166.39	163.69	0.76	200	KE-237	163.42	250
K-OF-55	167.03	165.2	0.39	200	KE-247	165.1	250
K-OF-56	167.55	166.4	2.88	150	KH-C-182	166.38	200
K-OF-57	156.2	155.13	0.44	150	KE-34	154.2	250
K-OF-58	164.23	160.66	0.03	150	KE-638	159.93	250
K-OF-59	164.23	161.64	0.02	150	KE-637	160.61	250
K-OF-60	162.53	161.41	0.45	200	KE-545	156.22	250
K-OF-61	155.88	154.82	0.69	150	KE-30	154.48	250
K-OF-62	155.2	153.84	0.95	150	KE-35	153.36	250
K-OF-63	155.62	154.53	1.14	150	KE-31	154.23	250
K-OF-64	163.66	162.54	1.21	200	KE-650	158.48	250
K-OF-65	163.6	160.94	1.43	200	KE-653	158.05	250
K-OF-66	166.3	165.07	1.3	200	KE-158	164.09	250
K-OF-67	162.56	161.76	4.08	200	KE-214	158.01	250
K-OF-68	165.56	164.29	1.23	200	KE-215	161.03	250
K-OF-69	167.09	166.03	1.25	150	KE-654	165.44	250
K-OF-70	162.81	158.54	0.3	150	KE-177	158.29	250
K-OF-71	166.43	164.73	0.14	150	KE-236	163.45	250

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	Elevation (Ground) (m)	Elevation (Invert) (m)	Flow (Total Out) (L/s)	Dia of Pipe in mm	Existing Connecting Manhole Number	Existing Connecting I.L. (m)	Existing Connecting Dia in mm
K-OF-72	167.26	165.54	0.33	150	KE-210	162.26	250
K-OF-73	167.08	164.57	0.43	150	KE-211	162.1	250
K-OF-74	164.33	160.91	1.03	150	KE-240	160.62	250
K-OF-75	160.8	158.53	0.25	150	KE-583	157.99	250
K-OF-76	162.71	161.22	0.07	150	KE-65	159.79	250
K-OF-77	164.1	163.04	0.06	150	KE-309	162.36	250
K-OF-78	165.06	163.58	0.18	150	KE-408	163.48	250
K-OF-79	165.58	164.39	0.04	150	KE-344	164.29	250
K-OF-80	164.97	163.91	0.07	150	KE-351	163.76	250
K-OF-81	161.21	160.14	0.38	150	KE-64	159.98	250
K-OF-82	163.15	161.42	1.41	200	KE-692	157.26	300
K-OF-83	161.48	160.37	1.35	200	KE-242	157.47	300
K-OF-84	168.47	165.94	1.64	200	KE-655	165.3	250
K-OF-85	166.59	165.47	1.25	200	KE-677	164.54	250
K-OF-86	160.08	158.97	1.37	200	KE-703	156.92	300
K-OF-87	167.21	163.83	0.24	200	KE-164	163.15	250
K-OF-88	154.35	153.8	0.23	150	KE-38	153.09	250
K-OF-89	163.81	162.75	0.82	150	KE-667	162.58	250
K-OF-90	165.38	164.26	1.31	200	KE-666	162.92	250

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	Elevation (Ground) (m)	Elevation (Invert) (m)	Flow (Total Out) (L/s)	Dia of Pipe in mm	Existing Connecting Manhole Number	Existing Connecting I.L. (m)	Existing Connecting Dia in mm
K-OF-91	164.77	163.66	0.44	200	KE-630	162.72	250
K-OF-92	166.55	165.07	0.72	150	KE-600	164.93	250
K-OF-93	164.39	162.64	0.9	150	KE-110	162.6	250
K-OF-94	162.84	161.73	0.43	200	KE-176	158.39	250
K-OF-95	166.92	164.2	0.17	150	KE-213	159.87	250
K-OF-96	166.86	165.63	0.7	150	KE-204	165.5	250
K-OF-97	166.51	165.4	0.14	150	KE-237	163.42	250
K-OF-98	167.37	164.99	0.31	150	KE-232	164.95	250
K-OF-99	163.38	162.27	0.18	200	KE-382	160.71	300
K-OF-100	165.5	164.44	0.29	150	KE-426	163.02	250
K-OF-101	164.98	163.58	0.67	150	KE-416	163.32	250
K-OF-102	165.22	164.15	0.13	150	KE-349	163.93	250
K-OF-103	167	165.39	0.05	150	KE-324	163.66	250
K-OF-104	163.1	160.9	0.22	150	KH-C-58	160.37	200
K-OF-106	159.99	158.01	7.87	200	KE-510	155.99	700
K-OF-107	162.88	158.88	4.42	200	KE-585	157.78	250
K-OF-108	163.74	162.49	10.04	200	KE-562	162.1	250
K-OF-109	165.22	163.99	0.26	150	KE-349	163.93	250
K-OF-110	164.41	162.05	0.22	150	KE-373	161.93	250

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	Elevation (Ground) (m)	Elevation (Invert) (m)	Flow (Total Out) (L/s)	Dia of Pipe in mm	Existing Connecting Manhole Number	Existing Connecting I.L. (m)	Existing Connecting Dia in mm
K-OF-111	162.44	159.79	0.04	150	KE-48	159.69	250
K-OF-112	158.78	156.56	2.22	150	KH-C-26	156.31	200
K-OF-113	166.51	165.41	0.13	150	KE-603	165.39	250
K-OF-114	162.99	158.16	1.12	200	KE-268	156.66	600
K-OF-115	164.73	163.49	0.54	150	KE-560	162.96	250
K-OF-116	163.08	161.87	0.39	150	KE-340	161.55	250
K-OF-117	164.46	163.4	0.18	150	KE-375	162.72	250
K-OF-118	164.98	163.87	0.25	200	KE-363	163.49	250
K-OF-119	158.13	156.19	0.71	200	KE-515	155.76	700
K-OF-120	158.16	157.1	0.18	150	KE-533	156.99	250
K-OF-121	157.73	156.12	6.41	200	KE-537	155.3	1000
K-OF-122	165.15	162.6	2.06	150	KE-631	162.58	250
K-OF-123	165.54	164.04	3.31	150	KE-680	164.02	250
K-OF-125	157.91	156.84	1.08	150	KE-711	156.48	250
K-OF-126	163.75	161.5	0.54	200	KE-689	157.49	300
K-OF-127	164.29	162.12	2.03	200	KE-638	159.93	250
K-OF-128	164.94	163.29	0.07	150	KE-423	163.23	250
K-OF-129	165.89	164.42	0.41	200	KE-464	162.24	250
K-OF-130	165.29	164.23	1.37	150	KE-681	163.79	250

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	Elevation (Ground) (m)	Elevation (Invert) (m)	Flow (Total Out) (L/s)	Dia of Pipe in mm	Existing Connecting Manhole Number	Existing Connecting I.L. (m)	Existing Connecting Dia in mm
K-OF-131	163.65	162.85	0.91	200	KE-650	158.48	250
K-OF-132	163.94	162.83	0.75	200	KE-648	161.04	250
K-OF-133	158.49	157.37	0.11	200	KE-572	157.12	250
K-OF-134	158.33	157.22	0.14	200	KE-573	156.33	250
K-OF-135	158.02	156.95	0.29	150	KE-42	155.98	250
K-OF-136	166.83	165.77	0.66	150	KE-725	165.85	200
K-OF-137	164.38	161.77	1.64	200	KE-683	160.77	250
K-OF-138	164.49	163.38	3.07	200	KE-672	161.15	250
K-OF-139	165.25	163.7	0.79	200	KE-403	163.62	250
K-OF-140	164.05	160.98	0.84	150	KE-636	160.82	250
K-OF-141	154.14	153.39	0.48	150	KE-38	153.09	250
K-OF-142	166.63	165.57	0.5	150	KE-245	165.34	250
K-OF-143	164.27	161.52	1.05	150	KE-634	161.27	250
K-OF-144	164.23	161.95	1.31	200	KE-635	161.23	250
K-OF-145	164.31	163.02	2.79	200	KE-696	162.96	250
K-OF-146	157.31	156.08	4.36	200	KE-20	154.44	250
K-OF-147	167.13	165.65	0.63	200	KE-139	165.51	250
K-OF-148	162.88	158.82	0.67	150	KE-522	158.54	250
K-OF-149	160.81	158.7	0.14	150	KE-83	157.32	250

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	**Elevation (Ground) (m)**	**Elevation (Invert) (m)**	**Flow (Total Out) (L/s)**	**Dia of Pipe in mm**	**Existing Connecting Manhole Number**	**Existing Connecting I.L. (m)**	**Existing Connecting Dia in mm**
K-OF-150	158.36	157.59	1.75	150	KE-84	157.19	250
K-OF-151	165.14	163.91	2.04	200	KE-558	163.08	250
K-OF-152	164.88	163.82	0.12	150	KE-352	163.73	250
K-OF-153	157.15	156.04	0.31	200	KE-549	155.32	250
K-OF-154	157.09	156.02	0.4	150	KE-93	155.86	250
K-OF-155	156.82	153.03	661.26	-	STP	-	-

6.2.8.2. Sewage pumping main

At present the pumping main from Kolhai IPS is pumped upto Manhole no. M-EMH-152 and further by gravity reaches Nagla Mewati MPS. From Nagla Mewati MPS pumped to existing 24 MLD STP at Dhandupura for taj Ganj Zone. As the existing STP is in adequate for 2035 sewer generation. New pumping main of 600mm DI-K7 for a length of 3790m is proposed to pump sewage from Kolhai IPS to proposed Jal Nigam 100 MLD capacity STP under Namami Gange scheme inlet chamber at existing 78 MLD STP campus.

Replacement of pumping plants proposed at Kolhai IPS will be executed at the fourth year of O&M period i.e at 2023-2024. Until 2023-2024 the existing system will continue.

The alignment of proposed pumping main is shown in the drawing below.

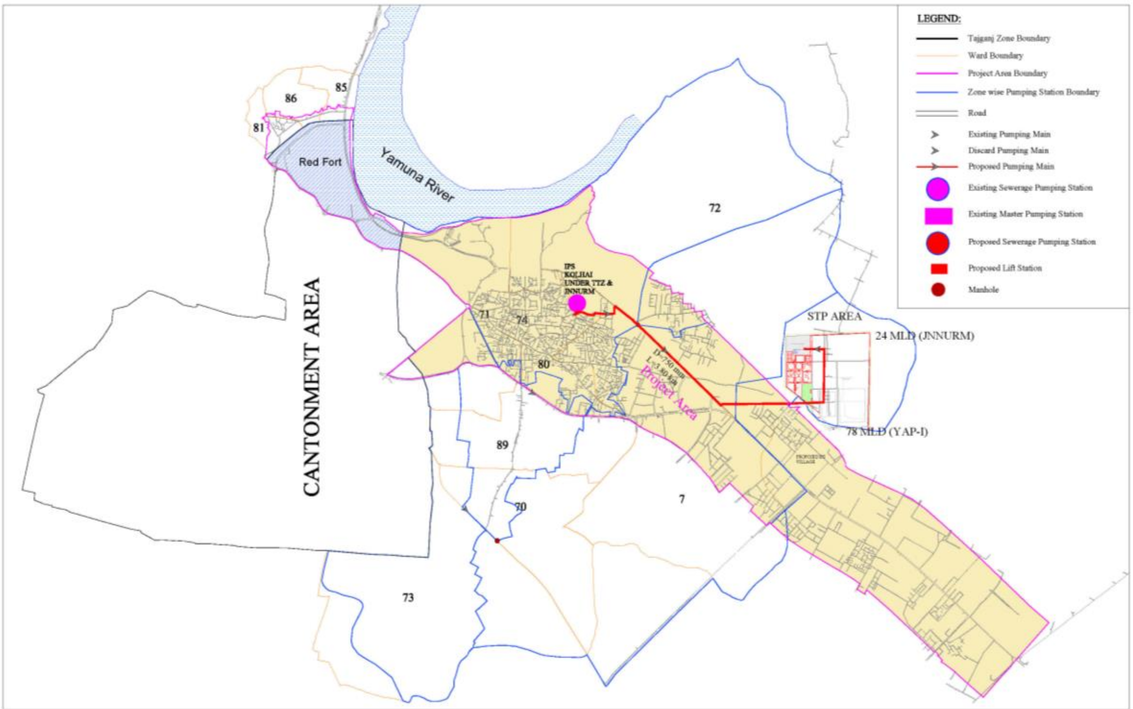


Figure 7: Proposed pumping main from Kolhai IPS to proposed STP

6.2.2. Zone – Nagla Mewati

6.2.2.1. Sewer Collection system

The missing links of zone Nagla Mewati is proposed to connect to existing system and further by gravity to MPS. The Hydraulic adequacy of the existing system is verified. The details of proposed network and integrating with existing manholes are tabulated below.

Table 24: Abstract of proposed sewer network in Nagla Mewati

Material	Sewer depth/dia	150	200	300	350	Total
HDPE DWC	3	145	445	145	0	735
	3.5	129	462	120	0	711
RCC NP3	3	0	36	0	0	36
	3.5	0	62	0	140	202
	4	32	215	0	148	396
	4.5	33	298	0	0	331
	5	33	223	0	77	333
	5.5	0	249	0	91	339
	6	0	194	0	432	626
	6.5	0	30	0	861	891
	7	0	0	0	82	82
Total		**5808**	**4757**	**265**	**1830**	**12660**

Table 25:Zone Nagla Mewati Details of Proposed sewer lines and connecting manhole details

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	**Elevation (Ground) (m)**	**Elevation (Invert) (m)**	**Flow (Total Out) (L/s)**	**Dia of Pipe in mm**	**Existing Connecting Manhole Number**	**Existing Connecting I.L. (m)**	**Existing Connecting Dia in mm**
M-OF-1	167.21	164.2	3.75	200.00	M-EMH-50	163.79	250.00
M-OF-2	167.6	163.66	6.18	200.00	M-EMH-51	163.59	250.00
M-OF-4	165.97	164.19	0.27	150.00	M-EMH-32	164.12	250.00
M-OF-5	165.93	164.68	0.36	150.00	M-EMH-23	164.17	250.00
M-OF-6	165.97	163.88	0.67	150.00	M-EMH-33	163.76	250.00
M-OF-7	166.32	160.1	6.54	200.00	M-EMH-43	158.37	500.00
M-OF-8	167.35	166.08	0.03	150.00	M-EMH-218	164.4	250.00
M-OF-9	166.74	159.84	59.08	350.00	M-EMH-217	158.96	600.00
M-OF-10	167.36	165.15	10.75	200.00	M-EMH-47	164.52	250.00
M-OF-11	166.89	165.54	1	200.00	M-EMH-3	165.2	300.00
M-OF-12	166.31	160.65	0.72	200.00	M-EMH-11	160.59	250.00
M-OF-13	166.28	163.93	0.18	150.00	M-EMH-10	163.63	250.00
M-OF-14	166.39	159.94	0.99	200.00	M-EMH-12	159.87	250.00
M-OF-15	165.39	163.81	0.05	150.00	M-EC-13	163.75	250.00
M-OF-16	166.79	162.89	0.49	200.00	M-EMH-191	160.41	500.00
M-OF-17	166.63	165.21	0.93	200.00	M-EMH-53	163.18	250.00
M-OF-18	167	163.4	1.44	200.00	M-EMH-52	163.36	250.00
M-OF-19	167.29	163.24	0.57	200.00	M-EMH-215	159.35	300.00
M-OF-20	166.35	162.74	0.41	200.00	M-EMH-190	160.51	500.00

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	Elevation (Ground) (m)	Elevation (Invert) (m)	Flow (Total Out) (L/s)	Dia of Pipe in mm	Existing Connecting Manhole Number	Existing Connecting I.L. (m)	Existing Connecting Dia in mm
M-OF-21	166.7	162.96	0.49	200.00	M-EMH-72	162.93	250.00
M-OF-22	167.43	165.89	0.07	150.00	M-EMH-119	165.88	250.00
M-OF-23	166	164.37	0.12	150.00	M-EMH-31	164.27	250.00
M-OF-24	166.28	164.09	2.45	200.00	M-EMH-11	160.59	250.00
M-OF-25	167.19	164.36	0.05	150.00	M-EMH-139	163.98	250.00
M-OF-26	167.37	165.93	0.03	150.00	M-EMH-119	165.88	250.00
M-OF-27	167.36	165.87	0.03	150.00	M-EMH-126	164.43	250.00
M-OF-28	166.61	163.22	0.45	150.00	M-EMH-95	163.17	250.00
M-OF-29	167.47	164.76	2.88	200.00	M-EMH-48	164.42	250.00
M-OF-30	167.09	163.83	0.65	200.00	M-EMH-150	163.29	300.00
M-OF-31	165.83	163.41	4.7	200.00	M-EMH-34	163.36	250.00
M-OF-32	167.4	165.59	0.07	150.00	M-EMH-127	164.41	250.00
M-OF-33	167.01	164.99	0.07	150.00	M-EMH-122	164.73	250.00
M-OF-34	166.83	164.84	0.13	150.00	M-EMH-121	164.88	250.00
M-OF-E- PS	166.53	157.63	868.91	-	STP	-	-
M-OF-LS	166.2	160.96	3.25	200	M-EMH-134	165.25	250

6.2.2.2. Sewage lifting stations

A lifting station M-LS is proposed to collect sewage from missing links by pumping main connects to existing manhole no. M-EMH-134 by 150mm DI-K7 main for a length of 50m. and further carried to master pumping station at Nagla Mehwati by gravity. Pumping station is provided with all electrical and mechanical components with power backup arrangements.

6.2.3. Zone – Kalalkheria & Mayapura

6.2.3.1. Sewer Collection system

The added villages of Kalalkheria and Mayapura villages doesn't have existing sewerage infrastructure. Both the villages are located in the project area and experiencing faster growth rate. The details of the proposed sewer network are tabulated below.

Table 26: Abstract of proposed sewer network in Kalalkheria & Mayapura

Material	Sewer depth/dia	150	200	250	300	350	400	Total
HDPE DWC	1.00	4263	0	74	30	0	0	**4368**
	1.50	11040	172	0	207	0	0	**11419**
	2.00	5462	585	0	118	0	0	**6165**
	2.50	2933	919	0	0	0	0	**3852**
	3.00	1720	1313	0	0	0	0	**3033**
	3.50	646	1532	0	0	0	0	**2177**
RCC NP3	3.50	0	79	0	0	0	0	**79**
	4.00	564	1381	0	130	0	0	**2074**
	4.50	280	1034	0	240	192	0	**1746**
	5.00	54	848	0	0	295	0	**1197**
	5.50	0	383	52	0	202	0	**638**
	6.00	0	0	266	60	98	307	**732**
Total		**26960**	**8246**	**393**	**785**	**788**	**307**	**37480**

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	Elevation (Ground) (m)	Elevation (Invert) (m)	Flow (Total Out) (L/s)	Dia of Pipe in mm	Existing Connecting Manhole Number	Existing Connecting I.L. (m)	Existing Connecting Dia in mm
V-OF-LS	165.82	159.66	36.754	350	V-PMH-90	165.35	165.08
V-OF-PS	165.91	159.61	67.836	-	STP	-	-

6.2.3.2. Sewage pumping station

The zone doesn't have sewerage facilities. so, land has been identified with help of elected representatives and new pumping station is proposed to collect entire sewerage from Kalalkheria and Mayapura villages. The pumping station is of 5m inner diameter with detention time of 3.75 minutes of ultimate peak flow. Submersible pumps capable of pumping lean flow and peak flow is proposed with electrical and power backup arrangements.

6.2.3.3. Sewage pumping main

The sewage will be pumped to the proposed STP at Dhandupura Village. New feasible pumping main alignment has been identified and as per economical size calculations 200mm DI-K7 pipe for a length of 1815m is proposed with all necessary valve arrangements. The alignment of proposed pumping main is shown in the diagram below.

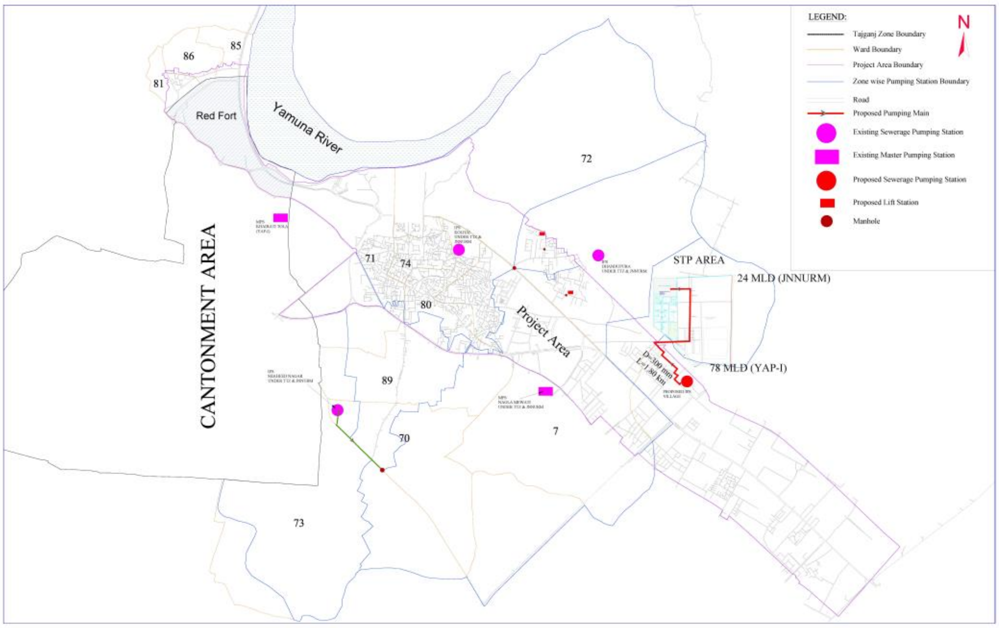


Figure 8: Proposed pumping main from IPS at Tora village to proposed STP

6.2.4. Zone – Dhandupura

6.2.4.1. Sewer Collection system

The existing sewerage system of Dhandupura village is collected at IPS located at Dhandupura and further pumped to MPS at Nagla Mewati. The entire sewage from Dhandupura will be treated at existing Taj Ganj STP. The details of the proposed sewer network are tabulated below.

Table 27: Abstract of proposed sewer network in Dhandupura

Material	Sewer depth/dia	150	200	Total
HDPE DWC	1.00	476.42	96.39	**573**
	1.50	549.83	26.84	**577**
	2.00	328.2	0	**328**
	2.50	98.68	61.83	**161**
	3.00	88.62	38.09	**127**

Material	Sewer depth/dia	150	200	Total
RCC NP3	4.00	0	10.42	**10**
	5.00	0	10.46	**10**
	5.50	0	31.2	**31**
	6.00	0	30.98	**31**
	6.50	0	36	**36**
Total		**1542**	**342**	**1884**

Table 28: Zone Dhandupura - Details of Proposed sewer lines and connecting manhole details

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	**Elevation (Ground) (m)**	**Elevation (Invert) (m)**	**Flow (Total Out) (L/s)**	**Dia of Pipe in mm**	**Existing Connecting Manhole Number**	**Existing Connecting I.L. (m)**	**Existing Connecting Dia in mm**
D-OF-LS-1	159.38	153.01	3.45	200.00	D-EMH-42	160.28	250.00
D-OF-1	163.26	159.84	0.12	150.00	D-EMH-72	159.62	250.00
D-OF-2	166.4	165.14	0.05	150.00	D-EMH-47	164.99	250.00
D-OF-3	164.68	162.61	0.04	150.00	D-EMH-70	162.59	250.00
D-OF-4	165.25	163.63	0.03	150.00	D-EMH-36	163.31	250.00
D-OF-5	163.64	160.77	0.09	150.00	D-EMH-74	159.22	250.00
D-OF-6	163.02	160.27	0.05	150.00	D-EMH-44	160.14	250.00
D-OF-7	162.43	160.36	0.03	150.00	D-EMH-43	160.24	250.00
D-OF-8	163.84	160.21	0.07	150.00	D-EMH-18	160.01	250.00
D-OF-9	164.14	162.1	0.03	150.00	D-EMH-11	162.05	250.00
D-OF-10	163.69	160.41	0.02	150.00	D-EMH-76	159.08	250.00
D-OF-11	164.43	161.92	0.46	150.00	D-EMH-31	161.67	250.00
D-OF-12	163.83	161.61	0.05	150.00	D-EMH-34	161.42	250.00
D-PS-1	165.14	157.97	41.07	-	PS to Me-M-EMH-152	-	-

6.2.4.2. Sewage lifting station

A lifting stations D-LS is proposed to integrate proposed sewer network with existing system is pumping from proposed lift station of 3m dia to existing manhole no.D-EMH-42 and further carried to zonal pumping station at Dhandupura. Length of pumping main is 170m of 150 mm DI-K7 pipe with all pumping and power backup arrangements

6.2.5. Zone – Khairati Tola

6.2.5.1. Sewer Collection system

The existing sewerage system of wards 81(P), 85(P) & 86(P) are part of central zone (Khairati Tola). The uncovered sewer network is analysed and integrated with existing system. The entire sewage from central zone is collected at IPS at Khairati Tola and further pumped to MPS at Nagla Mewati. The details of the proposed sewer network are tabulated below.

Table 29: Abstract of proposed sewer network in Khairati Tola

Material	Sewer depth/dia	150	200	250	Total
HDPE DWC	1.00	107.31	504.21	200.83	**812**
	1.50	232.29	496.02	32.29	**761**
	2.00	46.54	160.77	164.97	**372**
	2.50	0	58.33	0	**58**
Total		**386**	**1219**	**398**	**2004**

Zone Dhandupura - Details of Proposed sewer lines and connecting manhole details

Proposed Outfall Details					Existing Manhole Details where Proposed Outfalls are Linked		
Label	Elevation (Ground) (m)	Elevation (Invert) (m)	Flow (Total Out) (L/s)	Dia of Pipe in mm	Existing Connecting Manhole Number	Existing Connecting I.L. (m)	Existing Connecting Dia in mm
C-OF-1	152.82	151.97	38.39	250.00	C-E-MH-2	149.3	1600
C-OF-2	157.1	156.25	36.1	250.00	C-E-MH-1	154.09	1400

7. SEWAGE PUMPING STATIONS AND SEWAGE LIFT STATIONS

7.1. Sewage Pumping stations

Table 30:Details of flow

Location of SPS	G.L. (m)	I.L of Last MH	Incoming Sewer Dia (mm)	2035			Pumping Main	
				Peak Flow (lpm)	Ave. Flow (lpm)	Head in m	Length in m	Dia in mm
Kolhai SPS	156.82	153.03	1000	13698	6088	54	3790	600
New IPS	165.91	157.93	450	2808	468	42	1815	200

Table 31: Details of pumps, Pipes. valves and fitting sizes

Sl.No.	Name of pumping / lifting station	Peak Flow				
		Number of pumps (W)	Number of pumps (S)	Duty of each pump (lpmxm)	Rating of each pum (kW/HP)	Delivery size in mm
1	Kohlai SPS to STP	2	-	13698 lpm x 54m	242/324	350
2	New SPS to STP	1	-	2808 lpm x 42m	39/52	150
3	Dandupura LS to EMH-42	1	-	144 lpm x 17m	1.2/2	100
4	Mewati LS to EMH-134	1	-	134 lpm x 14m	0.9 / 1.2	100
5	Proposed lift station at Kalalkeria	1	-	1522 lpm x 26m	17/23	150

Sl.No.	Name of SPS	Average Flow				
		Number of pumps (W)	Number of pumps (S)	Duty of each pump (lpmxm)	Rating of each pum (kW/HP)	Delivery size in mm
1	Kohlai SPS to STP	2*	-	6088 lpm x 54m	107/144	250
2	New SPS to STP	2*	-	468 lpm x 42m	7.0/9.0	100

Total load and Transformer ratings for the above SPS are annexed

Lighting arrangement , driking water arragement are made along with SCADA for the above SPS

Details of transformer and other electrical gears/panel details are show I the SLDs annexed.

I.No.	Name of pumping / lifting station	Lean flow (0.60 of Ave. flow cum/day)	Average flow (cum/day)	Peak flow (2.25 of Ave. flow cum/day)	Dia of pipe DI-K7 pipe (mm)	Depth of well (m)	Difference in ground level (m)	Inlet chamber height (m)	Friction loss in pumping main (m)	Minor losses (m)	Pumping station losses (m)	Residual head (m)	Total head (m)
1	Kohlai SPS to STP	10520	17533	39449	600	10.50	12.20	5.00	18.50	1.85	2.50	3.00	53.55
2	New SPS to STP	809	1348	4044	200	9.18	2.17	5.00	18.00	1.80	2.50	3.00	41.65
3	Dandupura LS to EMH-42	41	69	207	150	7.40	2.59	0.00	1.00	0.10	2.50	3.00	16.59
4	Mewati LS to EMH-134	52	86	193	150	6.31	0.50	0.00	1.00	0.10	2.50	3.00	13.41
5	Proposed lift station at Kalalkeria	438	730	2191	150	7.55	0.47	0.00	10.80	1.08	2.50	3.00	25.40

Sl.No.	Name of pumping / lifting station	Lean flow (0.60 of Ave. flow		Average flow		Peak flow		Number of Pumps (W)		Head
		cum/day	cum/s	cum/day	cum/s	cum/day	cum/s	Peak flow	Ave flow	m
1	Kohlai SPS to STP	10520	0.122	17533	0.203	39449	0.457	2	2	54
2	New SPS to STP	809	0.009	1348	0.016	4044	0.047	1	2	42
3	Dandupura LS to EMH-42	41	0.0005	69	0.0008	207	0.0024	1+1	-	17
4	Mewati LS to EMH-134	52	0.001	86	0.001	193	0.002	1+1	-	14
5	Proposed lift station at Kalalkeria	438	0.005	730	0.008	2191	0.025	1+1	-	26

8. Sewage Treatment Plant

8.1. Necessity of Sewage Treatment Plant (STP)

For better hygienic conditions in the town Sewage & sullage catered from habitation is required to be treated as per the CPHEEO norms. During discussion with Jal Nigham officials bout the proposals, it was suggested to treat at proposed 100 MLD STP under Namami Gange scheme within the existing 78 MLD STP campus. Hence provision for Sewage Treatment Plant (STP) is not proposed in the scope of work.

For treatment of sewage, estimation of sewage generation with respect to population has been worked out accordingly capacity required for treating sewage flow for intermediate year 2031 and ultimate year 2046 is tabulated below.

Table 32: Sewage Generation and STP Capacity Required

Name of the Sewerage Sub Zone		Sewage Generation (Mld)			Existing STP Capacity (Mld)			STP Capacity Required (Mld)		
		2020	2035	2050	2020	2035	2050	2020	2035	2050
Mewati MPS	Mewati	10.07	14.53	21.19	**24.00**	**24.00**	**24.00**	**-**	**-**	**6.89**
	Dhandupura	0.47	0.67	0.97						
	Shaheed Nagar	4.14	5.98	8.73						
	Total	**14.68**	**21.18**	**30.89**						
Kolhai IPS	Kolhai	11.23	16.33	23.83	**-**	**-**	**-**	**12.08**	**17.57**	**25.64**
	ABD Area Villages	0.85	1.24	1.81						
	Total	**12.08**	**17.57**	**25.64**						

It is proposed to treat 18 MLD sewage from the Kolhai SPS & proposed IPS at Tora village at Jal Nigam proposed 100 MLD capacity STP under Namami Gange scheme near existing 78 MLD STP upto the year 2035.

9. VACCUM SEWER SYSTEM

During the supreme court committee review meeting held on 28.08.2018, it was suggested to adopt vacuum sewer system as pilot study for locations where lifting stations are proposed. So two locations at Kohlai zone are considered as pilot study. The detailed designs, drawings and cost estimates are submitted as annexed as volume-V

10. CONCLUSION

This project will benefit for a population of about 103351 Nos. and 17225 households and tourist of ABD area. By implementing this project the entire population of ABD area will have safe disposal of domestic wastewater and this will have improvement on public health of people. Vector borne diseases will be controlled and ensure safe and hygiene living condition of people of project area. Agra being an important tourist destination, Travellers will get protection from communicable and non-communicable diseases and infections. There is a scope for reuse of treated water for agriculture and green spaces. Thereby reduce thrust on ground water.

9. WAY FORWARD

To implement this project there are challenges encountered in many areas. Following are the key bottlenecks of the project to be addressed.

- The existing sewer network needs desilting and flushing as at many places sewer lines are choked and manholes are silted. So, the existing system needs desilting and flushing to ensure smooth flow in the existing system.
- Effective functioning of the existing system must be ensured before interlinking of proposed sewer network to the existing system.
- Necessary permissions for implementing this project like transfer of land ownership for construction of IPS, NH crossings, Railway crossings, Archaeological survey of India, National green tribunal, etc. needs to be cleared within stipulated time
- Taj Ganj being crowded area with narrow roads embedded with many underground utilities like existing sewerage, Torrent power line, Optical fibre cable, water supply pipelines etc. Challenge is foreseen to implement without destructing other existing utilities.
- 100% house sewer connections for the existing and proposed system to be ensured before commissioning of the project.

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