ID	Name	Discharge	Head	Motor	Operating	Daily Production	Remarks
		m^3/h	m	HP	Hours	MLD	
					Total	**67.92**	**say 68 MLD**

It is proposed to provide 3 submersible pump sets as standby to facilitate keep down time minimum.

The other 8TWs constructed by PHED are yet to be handed over to GMC and are of recent origin and hence replacement of pumps is not proposed.

It is proposed to provide one Electro-Magnetic type flow meter with AMR facility in the delivery pipe of each Tube Well for flow measurement along with one pressure gauge, one Non Return Valve, and Butterfly Valve. A sensor to measure water level in the Tube Well is also proposed to be installed. The sizes of flow meters and valves on each Tube Well are mentioned in the Drawing No.2.

7.3. ELECTRICAL SYSTEMS

The condition of electrical system on the tube wells is still bad. There is practically no protection provided in electrical system against single phasing, over load, earth fault etc. There are no meters installed like ampere meters, volt meters, energy meters, power factor meters etc. on these tube wells. It is therefore proposed to provide a new Electric panel in each Tube Well pump room with an air break Star Delta starter with necessary protection relay, meters and level indicating meter. The electrical system is proposed to be properly earthed as per rules. A Single Line Diagram for a typical electrical system of a Tube Well is given in drawing section in the Drawing No. 3

There are 5 TWs in Dandibagh campus with substantial discharge. The condition of 11/0415 KV substation of (300+250+100) KVA is not good. The transformers are old and have not undergone maintenance for long and need replacement. Protection for the Transformers either on HT side or on LT side is not available. It is proposed to renovate the substation by providing two 1000 KVA 11/0.415 KV transformers (1Working+1Stand by) with necessary protections through 11 KV VCB, LAs and ACB on LT side with proper cabling. A Single Line Diagram for the arrangement of substation is placed in Drawing No. 4

It is also proposed to construct a control room at Dandibagh campus for housing all switchgear and panels for centralised operation of all the 5 Tube Wells. This will reduce requirement of manpower for operation and also more effective control and supervision. Push button stations shall also be provided on each TW. A layout plan of substation, control room and tube wells at Dandibagh are placed in the drawing section in the Drawing No. 5. No intervention is proposed at the new PHED constructed wells.

The above interventions at Dandibagh campus are likely to provide sustained and dependable power supply to TWs located here. A 33 KV electric substation exists just outside Dandibagh campus connected to 132KV GSS. Thus we can safely assume that at least 23hours daily power supply will be available on sustained basis. Similarly, it has been informed that at TWs located elsewhere in the town power supply availability is 20 hours daily in general and the same has been adopted.

7.4. DISINFECTION SYSTEM FOR TUBE WELLS

At present water supply from the Tube Wells is made either directly to distribution network or through reservoirs. However, there is no disinfection arrangement for the water supplied.

It is therefore proposed to provide one Electro Chlorinator at each Tube Well capable of producing 1kg/hour chlorine. The raw material required in these chlorinators will be common salt. Provision has been made in the electrical panel proposed at each TW for power supply required for the electro chlorinator.

7.5. REHABILITATION OF PUMP ROOMS ON TUBE WELLS

The condition of Pump Rooms constructed on TWs is not good in many cases. The internal wiring is generally in precarious condition, doors and windows and in bad condition. It is therefore, proposed to construct new pump rooms at 6 locations and rehabilitate pump rooms by repair of civil construction, replacement of doors and windows wherever required and electric wiring for illumination at remaining 23 locations.

8. PROPOSED WATER SUPPLY SYSTEM LAYOUT

The proposed water supply system of Gaya will be divided in District Metered Areas. The water from the tube wells will be pumped through dedicated rising mains to the respective service storage capacities. As described below in Section 10, **Table 21**, 10 new service reservoirs are proposed and will be operated along with the 8 existing ones detailed above in the status of existing storage reservoirs and their health is depicted in **Table 5**.

From these reservoirs, the water will flow by gravity through transmission mains and distributed to each of the proposed 30 District Metered Areas connected to the transmission main through a Flow and Pressure Monitoring Station. The larger Reservoirs (Existing GLSRs) will supply several DMAs whereas for DMAS where no storage was until now available one Over Head Tanks will be provided, for each DMA. No other connection will be allowed to the Transmission Mains from Storage to DMAs.

All pipelines laid by PHED with a length of about 72 Km of Ductile Iron are proposed to be kept in operation, in spite of the fact that a large portion of them has not yet been handed over to GMC. All other existing pipe lines which are reported to be of Cast Iron and laid prior to 1982 will be decommissioned and replaced as the same have become very old and unsuitable for rehabilitation.

The decommissioning of the old pipelines is an important item to be considered in the Capital Works Contract to be laid as result of this report.

The length of new pipes to be laid is estimated at about 446 Km and presented in the sub-section 11.3. The pipe materials will be Ductile Iron for diameters 350 mm and above and HDPE for sizes up to 300 mm. This is based on the prevailing practice in most of the utilities in India as both HDPE and DI pipe provide excellent service for distribution system. However, looking to cost economy HDPE pipes of 110 mm and DI pipe in sizes 150 mm and above have been adopted.

In the frame of the activity related to the installation of customers' meters, also the old service connections will be renewed.

A drawing showing location of all existing and proposed service reservoirs, tube wells and existing and proposed transmission pipe lines is placed in the Drawing No. 19.

9. PROPOSED TRANSMISSION AND STORAGE SYSTEM

9.1. PROPOSED PUMPING MAINS

The existing tube wells at Dandibagh are already connected through three pumping mains to Brahmayoni SRs and accordingly no new transmission pipe line is proposed for them. Similarly, new tube wells constructed by PHED at Dandibagh are also connected by a separate pumping main to Shringh Sthan GLSR by a new transmission main and accordingly no new pumping main will be required for these tube wells.

All remaining tube wells are presently pumping water to the distribution system. However, in order to have equitable distribution of water in a sustained manner and use the production capacity of TW optimally, it is proposed to supply water through OHSRs or GLSRs on Hills. Table 20 details the lengths and sizes of pipe lines proposed to be provided to connect tube wells to respective Service Reservoirs. All pipes for pumping mains will be of Ductile Iron K9. The pipe sizes have been worked out in the design section based on the TW discharge capacity based on most techno-economic consideration over a period of 30 years.

Table 20: Details of Proposed Rising Mains

Tank ID No.	ID. No.	Name of Tube well	Discharge (m3/hr.)	Size of Rising Main (mm)	Length (m)
1	32	Kirl 1, Joda Masjid	150	150	10.0
		Combined Discharge of 2nos		450	40.0
4	28	Manpur	100	250	613.0
	33	Kirl 2, Muffassil Thana	170	250	261.0
		Combined Discharge of 2nos		350	1731.0
		Future TW after Y-2033		350	40.0
5	30	Khadigramodyog Lakhibagh	55	200	81.0
	34	Kirl 3, Near Bridge	75	200	355.0
		Combined Discharge of 2nos		200	1310.0
6&7	7	Panchayati Akhara No. 2	100	200	62.0
	17	Panchayati Akhara No. 3	100	200	58.0
		Combined Discharge of 2 & 3	200	350	309.6
	6	Panchayati Akhara No. 1	100	250	315.0
		Combined Discharge of 1,2,3	300	350	566.0
	24	Bageshwari Pachim 24	20	100	396.0
	31	Bageswari -Cotton mill Thana 31	36	150	596.0
		Combined Discharge of 31&24	56	200	948.2
	9	Dhobighat	40	150	690.0
		Combined Discharge of 9,24&31	96	250	140.0
		Combined Discharge of 6 no	396	400	126.0
8	18	Janata Colony 1	40	100	10.0

Tank ID No.	ID. No.	Name of Tube well	Discharge (m3/hr.)	Size of Rising Main (mm)	Length (m)
	19	Janata Colony 2	20	100	87.7
		Combined Discharge of 1&2	60	200	470.0
	10	Central School	75	150	53.0
	23	Bairagi Powerganj	55	150	152.7
		Combinded discharge of 10 &23	130	200	236.0
		combinded discharge of 4 nos	190	300	121.0
	27	Hata Godown	55	200	248.3
	25	Pitamaheshwar	75	200	300.5
		Combined discharge of 25&27	130	300	192.2
	12	Gurudwara	55	100	10.0
		Combined discharge of 12, 25&27	185	300	115.8
	11	Nigam Store	20	100	10.0
		Combined Discharge of 11,12,25,27	205	350	272.9
	14	New Godown	55	150	613.3
		Combined discharge of 5 no	260	300	197.7
		Combined discharge of all 9 no		350	136.0
9	26	Kauvasthan	20	100	1030.0
	20	Pilgrim Hospital	20	100	179.1
		Combined discharge of 20 & 26	40	100	22.7
	8	Azad Park	55	100	10.0
		Combined discharge of 3 nos		200	69.0
10	1	Dandibagh TW 1 (Existing pipe line)	220	300	
	4	Dandibagh TW 4 (Existing pipe line)	220	300	
	5	Dandibagh TW 5(Existing pipe line)	220	350	
		Com Dis 1,4 &5 (Existing pipe line)	660	600	
11	22	Bypass 22 (Existing pipe line)	75	200	
	2	Dandibagh TW 2 (Existing pipe line)	220	300	20.0
		Junction (Existing pipe line)	295	450	1509.0
12	3	Dandibagh TW 3 (Existing pipe line)	220	350	
13	36	Kirloskar (Existing pipe line)	170	250	
	37	Kirloskar (Existing pipe line)	170	250	
	38	Kirloskar (Existing pipe line)	170	250	
	39	Kirloskar (Existing pipe line)	75	150	
		Com dis of 36,37,38,39 (Existing pipe line)	585	450	

Tank ID No.	ID. No.	Name of Tube well	Discharge (m3/hr.)	Size of Rising Main (mm)	Length (m)
	35	Kirloskar (Existing pipe line)	170	250	
		Combined discharge of 5 no. (Existing pipe line)	755	450	
				Total	**14714.6**

10. PROPOSED STORAGE CAPACITIES

10.1. LOCATION OF THE STORAGE CAPACITIES

The location of all existing Service Reservoirs is shown in the Drawing No. 16. This drawing also shows the location of proposed new reservoirs.

10.2. CAPACITY OF OVER HEAD TANKS

The water distribution system has been designed with formation of DMAs. The DMAs are connected to nearest SRs. An examination of existing capacities of reservoirs and water demand to be met has been done in the design section. Accordingly, in Phase I 9 new SRs are proposed, among them 6 No's are OHT and 1 GLSR are to be newly constructed & 2 existing GLSRs are to be demolished and two new GLSRs of proposed capacities are to be constructed at the same locations. All newly proposed OHSRs will have a staging of 21m and same has been incorporated in network design. Table 21 shows the location, the capacity, the DMAs served and the water demand of served DMAs. It is also proposed that 2 OHTs may be constructed after project period as the same are not immediately required due to less population density in these DMAs.

Table 21: Proposed Service Storages details

ID.	Reservoir Location	ML	Land required	DMAs connected	DMAs Demand (MLD)		TW
			(m x m)		2048	2018	Connected
1	Joda Maszid	2.15	30 x 30	2, 3	12.71	7.39	32
2	Patan Poli (Phase-II)	*1.0					
3	Budva Mahadev	1	30 x 30	1	2.25	1.18	Package-2
4	Mastalipur	2	24 x 37.5	4, 5	7.587	3.8	28, 33
5	Busunda Mela	2.15	30 x 30	6, 7	8.592	4.45	34,30
6 &7	Ramshila Hill GLSR	#0.22+ 2.6	24 x 40	8, 9	10.248	5.31	6, 7, 9, 17, 24,31
8	Murli Hills GLSR	#1.630		10	5.326	3.58	10, 11, 12, 14, 18, 19, 23, 25, 27
9	Ajad Park	#0.45		Ward 15, DMA 13	2.324	1.25	8, 20, 26
10c	Brahmayoni Hills GLSR	4.64	45 x 90	11, 12, 13, 14, 17,	68.763	41.44	1, 2, 3, 4, 5, 22
10d	Brahmayoni Hills GLSR	4.64					
10a	Brahmayoni Hills GLSR	#1.816		21, 22, 23, 24, 25, 26, 27			
10b	Brahmayoni Hills GLSR	#1.816					
11	Brahmayoni Hills GLSR	#3.632					
12	Brahmayoni Hills GLSR	#3.632					
13a+13b	Shringh Sthan	#4.54 & 3.7		15, 16, 18, 19, 20	32.698	14.59	35, 36, 37, 38, 39
14	Kharkura Raja koti	1.5	30 x 30	29	5.546	2.77	15, 16

16	Behind Delha PS	2.15	26 x 34.6	28, 30	7.27	3.5	Package-2

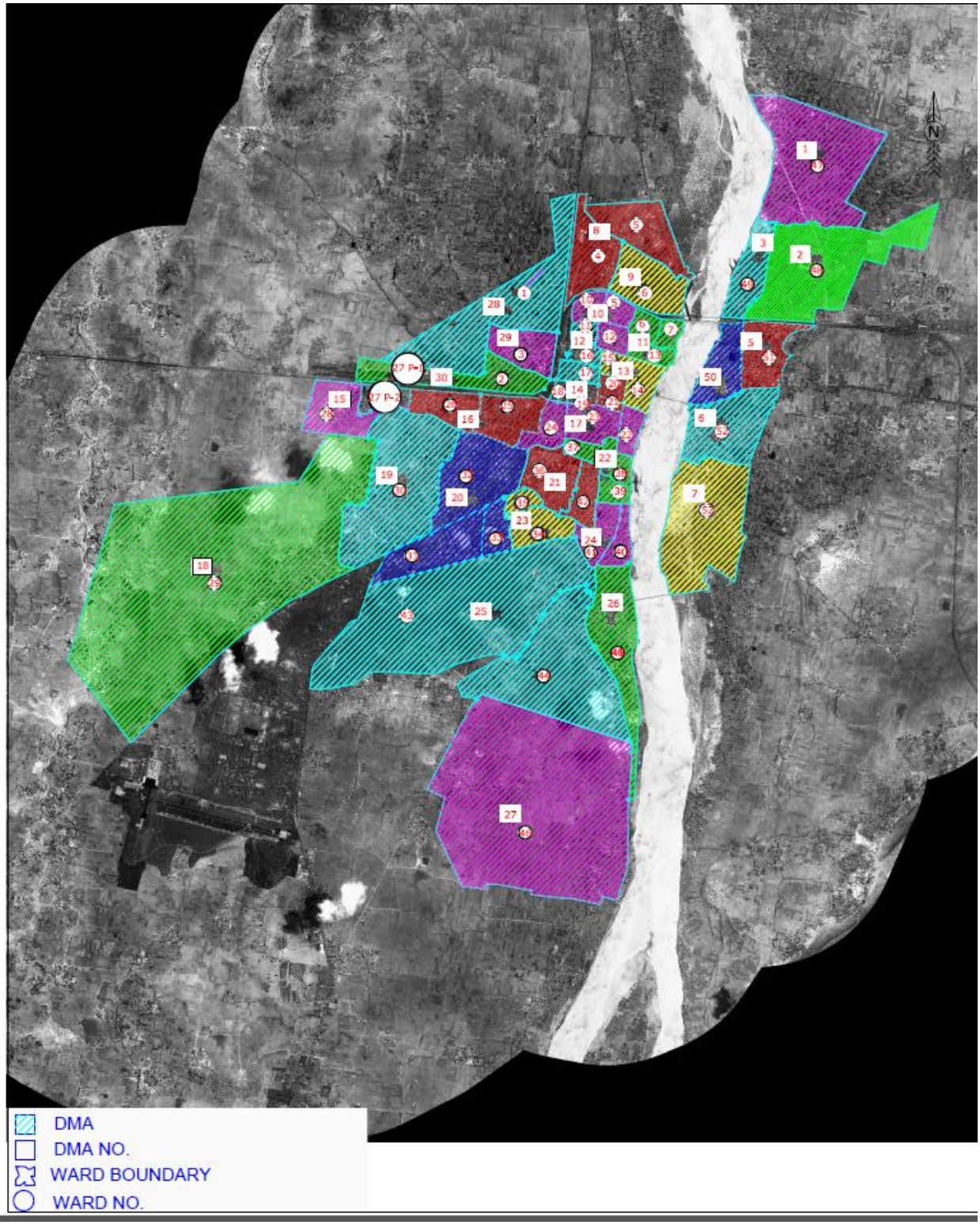
Note 1: #Existing Reservoirs

Note 2: *Reservoirs proposed in Phase II
Note 3: New reservoir of 3.7ML is proposed to be constructed near existing reservoir at Shring Sthan hills in Package-2

11. PROPOSED DISTRIBUTION SYSTEM

11.1. DEMARCATION OF DMAS

Figure 11-1: Demarcation of DMAs



The District Meter Area serve to better manage the distribution network, based on the pressure patterns control and on the water flows monitoring. A DMA is fed from few monitored input pipe lines and supply and consumption can be easily compared.

A DMA of the distribution system for Gaya town is covering 6 to 40 km of water supply pipelines and up to 4,000 and up to 7000 service connections in 2018 and 2048 respectively according to the present design. However further DMAs will be necessary as the network develops to the streets configuration at a certain target year. The DMAs have 1 to 3 monitored connections to transmission mains used to calculate and derive the water balance in that DMA.

Gaya will be divided in to 30 DMAs. Each DMA will be supplied with water from the storage tank with a dedicated feeder main. All DMAs are having separate monitoring stations at taping point from feeder mains.

The Detailed representation of DMA with municipal ward boundaries are shown in the Drawing No.18

The demarcation and details of DMAs like storage tanks, contributing municipal wards and length of pipes are shown below.

Table 22: Details of DMAs in Gaya

DMA No.	Population					No. of Connections for Year 2021	Length (m)	Tank ID
	Ward	2018	2021	2033	2048			
1	47	8922	9405	11490	14433	1649	19,631	1
2	48	15128	15948	19483	24473	4729	10,497	2
3	49	17322	18261	22308	28023	5281	12,078	3
4	50	17439	18385	22460	28213	3646	14,545	4
5	51	9495	10010	12229	15362	2119	9,753	
6	52	12276	12941	15810	19860	3838	20,847	5
7	53	13010	13715	16755	21047	2947	18,561	
8	5	4178	4404	5380	6759	1236	14,858	6 & 7
	4	14562	15351	18754	23557	2716		
9	6	15413	16249	19850	24935	3841	8,825	
10	9	6423	6771	8272	10391	261	14,852	8
	10	9196	9694	11843	14877	1989		
	12	11777	12415	15167	19052	3422		
13 (Pt-1)	15	8144	8585	10488	13175	2126	2,876	9
11	7	9707	10233	12501	15704	1208	13,831	10a+ 10b
	8	11987	12637	15438	19393	3747		
	13	4625	4876	5957	7483	793		
12	11	7585	7996	9768	12270	1958	9,805	
	16	7721	8140	9944	12491	2083		
	17	7185	7575	9254	11624	1809		
13 (Pt-2)	14	11719	12354	15092	18958	2736	4,555	
14	18	4884	5148	6290	7901	1389	10,947	

DMA No.	Population					No. of Connections for Year 2021	Length (m)	Tank ID
	Ward	2018	2021	2033	2048			
	19	5750	6061	7405	9302	1258		
	20	5120	5397	6594	8283	1295		
	21	3021	3185	3890	4887	1412		
15	28	11930	12577	15365	19300	2435		
	27 (pt-2)	17883	17910	18425	19288	2573	13,987	
16	26	7835	8260	10091	12676	1913		
	25	11575	12203	14908	18726	2320	22,072	
18	29	9406	9916	12114	15217	4146	40,970	13
19	30	17880	18849	23027	28926	4639	38,109	
20	31	9850	10384	12686	15935	1171		
	32	8282	8731	10666	13398	1464	29,472	
	33	5812	6127	7486	9403	1593		
21	36	14076	14839	18128	22772	2315		
	42	8278	8727	10661	13392	1369	19,149	
22	37	4115	4338	5300	6657	1085		
	38	11830	12472	15236	19139	1869	10,819	11
	39	6193	6528	7976	10018	1407		
23	34	12156	12815	15656	19666	2577		
	35	5583	5886	7190	9032	1165	14,351	
24	40	9604	10125	12369	15537	1920		
	41	7549	7958	9722	12212	1458	11,171	
25	43	11384	12001	14661	18417	2035		
	44	6489	6841	8357	10498	1277	33,739	
26	45	13986	14745	18013	22627	2801	13,996	12
27	46	10454	11021	13464	16913	2515	17,799	
17	24	7425	7827	9562	12011	1389		
	23	8041	8477	10356	13009	1579	17,389	
	22	9923	10461	12780	16053	1982		
28	1	10515	11085	13542	17011	3313	21,160	14
29	3	14412	15193	18561	23315	4788	10,366	15
30	2	9246	9747	11908	14958	2026		
	27part-1		943	4606	9644	135	12,264	16
Totals		**524297**	**552723**	**675237**	**848200**	**120747**	**513274**	

11.2. HYDRAULIC MODELING

The basic objective of the distribution system is to provide equitable distribution of water throughout the network with acceptable pressure. However, due to the addition of new localities and continuous growth of population the infrastructural setup needs to be upgraded periodically to meet the additional demand.

The distribution system is modelled and simulated with actual flow conditions. The process of simulation and model build is called as modelling. On built up of such model, improvements / additions are easy to perform.

11.2.1. COLLECTION OF FIELD DATA FOR PROJECT PLANNING

The GIS maps were used as primary information for preparation of Base Maps. GIS images of the Gaya town were made available from BUIDCo. It was assumed that the images are updated to show new roads and localities. Information related to the water supply distribution network was received from various interactions with the Public Health Engineering Department (PHED) and Gaya Municipal Corporation officials. Site investigations were conducted by the field staff to gather information related to the existing water supply status, sources, population etc. Since, it is difficult to authenticate every data made available; efforts have been made to cross check some of the data through specific inspections at site. For, most of the information data has been collected from the PHED and GMC, from hand-made sketches, tables and as well by direct interaction and personal visit to the area.

11.2.2. DIGITIZATION OF DATA

The information collected from PHED has been continuously updated on the base map of Gaya to create an information database for the present water supply distribution network. Such a database is essential not only for designing the distribution network but also for all future studies and improvements.

11.2.3. DEVELOPING THE NETWORK IN WATER GEMS SOFTWARE

The study of the existing distribution network has been done in Water GEMS V8i version, a computer programme that performs extended simulation for hydraulic and water quality behaviour within pressurized pipes. Water GEMS primarily is designed as a research tool for improving our understanding of the flow condition of water in a distribution system. Running under Windows, Water GEMS provides an integrated environment for editing network input data, running hydraulic and water quality simulations and reviewing the results in a variety of formats. These include colour coded network maps, data tables, time series graphs and contour plots.

The length of pipe line has been obtained from the digitized map. The value of ‘C’ has been assumed to be 140 & 145 for DI & HDPE pipes respectively for proposed for initial simulation for the distribution system. Nodes have been provided at all branches of the water supply network and also at junction of each road and where future branching of pipes may be required or contemplated. The elevation of each node was obtained from the digitized map of reduced level provided by previous consultant through BUIDCo. In case where the levels are not available on the map, the levels at such places were either interpolated or assumed.

11.2.4. STIPULATION OF PRESSURE IN THE DISTRIBUTION SYSTEM

Pressure in the water supply system is necessary to keep the water flowing through the distribution system. Pressure in an urban water supply is typically maintained at a certain minimum head at ground level at all the points in the system. As per CPHEEO manual, places where single storied buildings are predominant, 7.0 m pressure is to be maintained and where two storied buildings are

predominant, 12.0 m pressure is to be maintained. This can be achieved either by pumping or by pumping the water up into an overhead tank and conveying through gravity main.

Water GEMS output results compute pressures at various nodes in the system. Software incorporates friction head loss using the modified Hazen William's formula. In the software 10% of total length is increased for minor head losses for bends, fittings etc.

11.2.5. METHODOLOGY TO MODEL AND RUN THE DISTRIBUTION NETWORK IN WATER GEMS

As per the site visits and various discussions with the GMC and PHED officials the road and existing pipe line alignment is sketched on the background satellite image. Finally, GIS images are used as background in AutoCAD maps on which the pipe lines where digitized. This way the correct lengths are automatically calculated.

The distribution network is then marked and drawn as per decided alignment on the upgraded AutoCAD map of the area in the Water GEMS as shown in the following Figure 11-2.

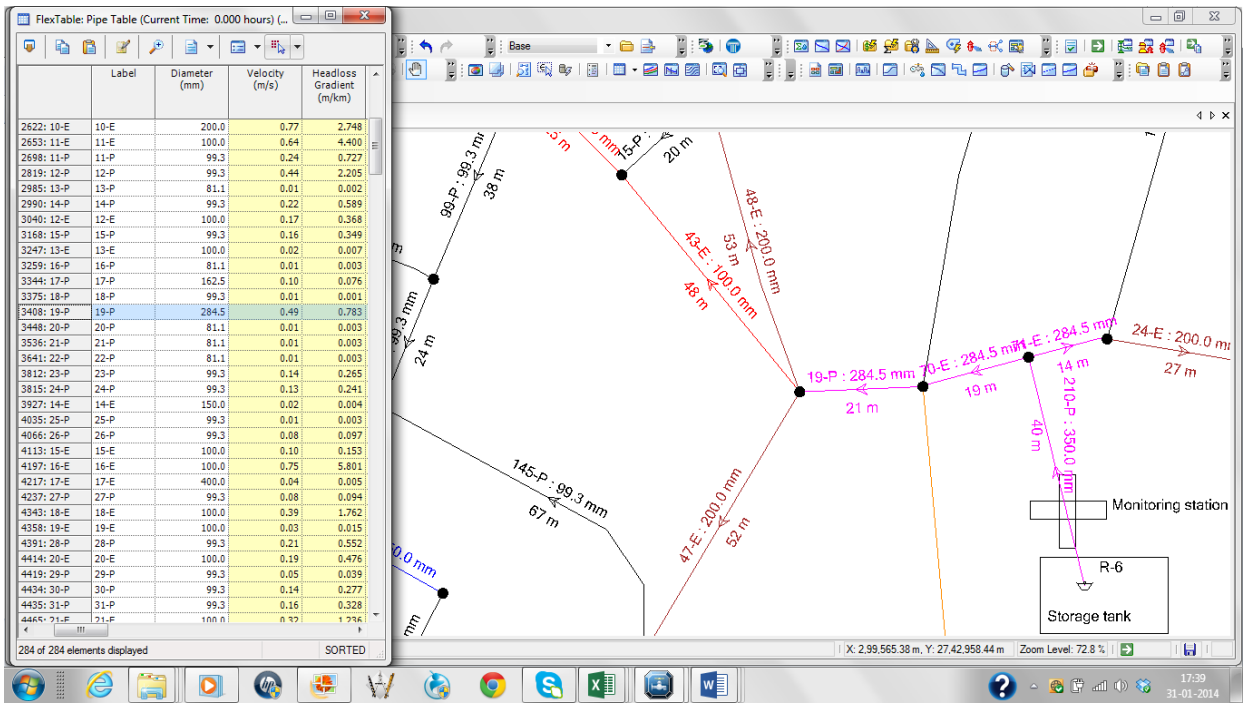
Nodes are provided at all branches of the proposed water supply network and also at junction of each road and where future branching of pipes may be required or contemplated.

Every node (junction) and link (pipe) has been furnished with a unique ID number like xxx and Pxxx, where xxx stands for Junction no. and P stands for prefix of pipe and xxx is pipe no. Prefixes are shown as E and P where E- existing and P-proposed.

The location of source points are located and marked on the Base Map. In this package the network is drawn from the source point i.e. from the overhead tank with given staging height and ground level tank. It should be noted that there is only one source point provided for each network of the DMA to have a better control on the flow. The network is then extended till the last node of the network.

The information regarding the pipe lengths for all the pipes and the elevation of all the nodes are fed into the software. The Figure 11-2 shows also the details of the procedure.

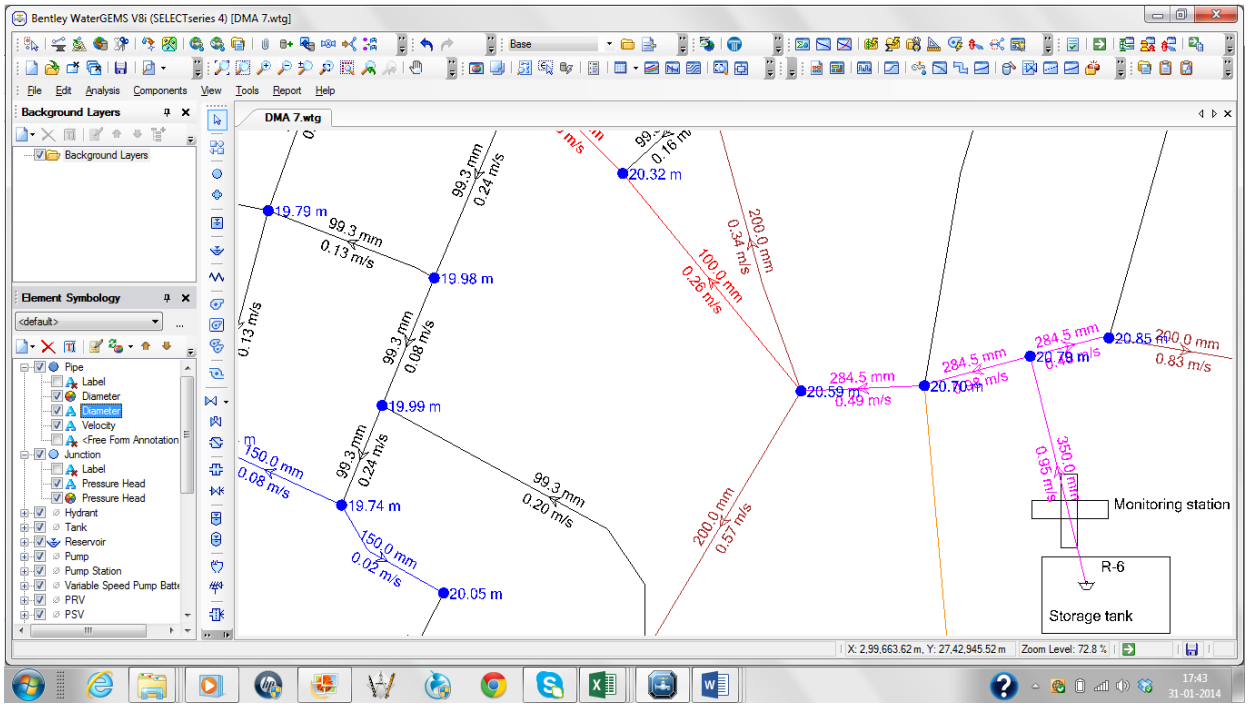
Figure 11-2: Representation of links attributes in the model



After feeding all the required data such as pipe lengths, elevation & base demand at every node, the model is ready to run. The pipe size is kept as DN 90 mm minimum and the model is run to check the too high velocity and points of negative pressure i.e. to identify the pipes which need to be increased. The points of negative pressure are identified and the pipes sizes are increased to achieve the residual pressure of minimum 12 m at the terminal nodes.

The Figure 11-3 shows the various pipe sizes in the network and the pressure obtained at every node. In order to emphasize the sizes of the pipes and the pressure in the nodes the background AutoCAD streets map is not shown in this figure but can be switched on in case of need.

Figure 11-3: Representation of Hydraulic Modelling Results



Significance of the colours of the pipes
Lime - 90 mm
Black - 110 mm
Deep sky blue - 150 mm(DI)
Red - 100 mm(DI)
Orange red - 200 mm
Cyan - 250 mm
Pink - 350 mm

Significance of the colours of the nodes (pressure)
Red < =12 m
Lime < =17 m
Blue < =30 m

11.3. PROPOSED DISTRIBUTION PIPELINES

The future Distribution Network will be composed of the pipeline and diameters shown below in the Table 23.

Table 23: Details of Proposed Distribution Network Pipes

Diameter (mm)	*Existing DI pipe lengths laid by Kirloskar Bros. for PHED*								
	100	150	200	250	300	350	400	450	
Total [m]	30755	14598	15492	2053	1246	1720	4319	2272	**72455**

Diameter (mm)	*Proposed HDPE (PN 6) pipe lengths*										
	110										
Total [m]	3,01,002										
Diameter (mm)	*Proposed DI K-7 pipe lengths*										
	150	200	250	300	350	400	450	500	600	700	
Total [m]	62354	29631	18919	9131	6321	4477	5376	2226	4897	2141	**446475**

The total length to be laid is 446475 m.

All existing pipelines laid before 1982, which are mostly of Cast Iron are proposed to be replaced. Special attention shall be given to their decommissioning.

The above length of 72455 m PHED pipe lines is based on GIS map prepared based on pipe lines marked in software, connected with proposed DMAS and designed with the help of M/S Kirloskar representative. However, actual length will be known only when the assets are handed over to GMC along with 'As Built Drawings' as agreed during a meeting in BUIDCO on 29th April 2014 by EE PHED Gaya.

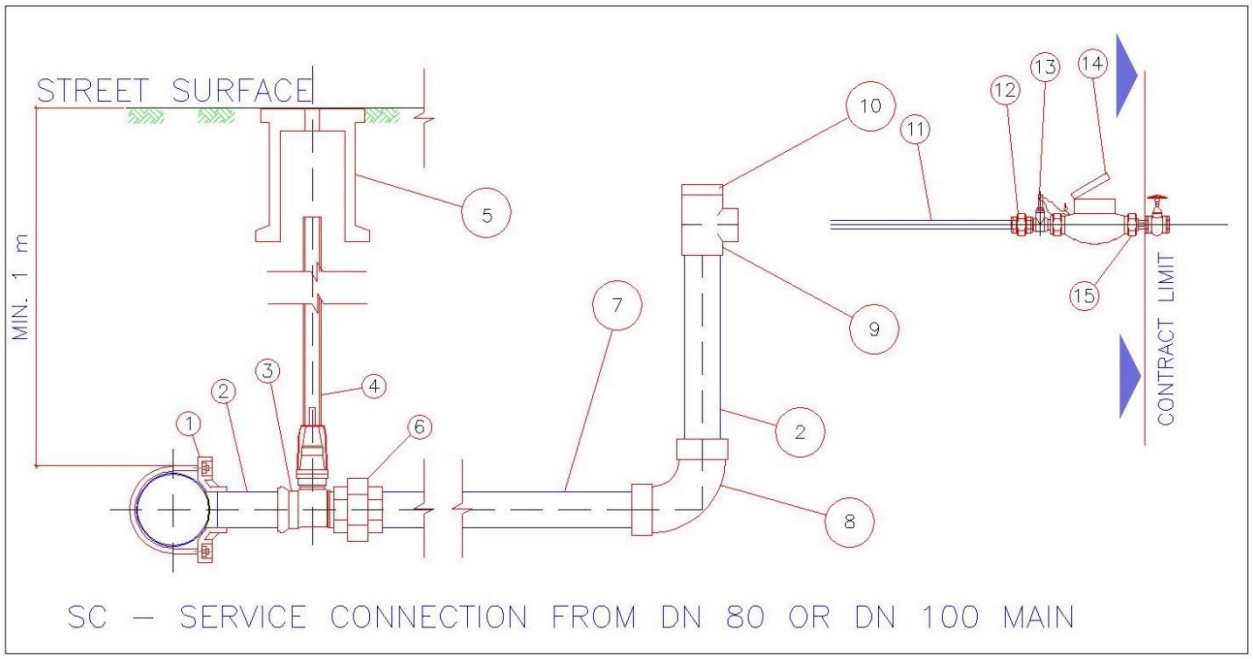
It is assumed that before the start of the capital investment works all the existing PHED pipelines laid by Kirloskar Brothers will be properly tested and commissioned and will be taken over by GMC. However, provision is made in the confidential cost estimate for replacement of 5% of pipes laid through PHED which are found to be leaking/un-repairable during execution/operation.

Details of the above DMA wise designs are placed in the Design section of the present report and shown in the drawings.

12. SERVICE CONNECTIONS AND METERING

All service connections shall be provided with water meter and shall consist of an arrangement similar to the one shown in the Figure 12-1 below.

Figure 12-1: Service Connections arrangement recommandations



Legend

1	Drilling Saddle for DN 80 and 100	9	T-Piece
2	Pipe Nipple, Dia.100, L=100 mm	10	Plug
3	Service Gate Valve (with brass union)	11	Pipe Nipple, Dia. 40, L=100mm
4	PVC Valve protection Bell and Pipe	12	Reduction or T-piece 100-40
5	Valve surface box	13	Anti-Fraud system stop cock
6	Union	14	Water Meter complete with brass union
7	MDPE Pipe,	15	Brass Coupling
8	Compression joints		

The main characteristic of the above recommendation is that the tapping either as above realised through a drilling saddle in existing pipes or by T-piece in new pipes, shall not be at the top of the distribution pipe barrel, but horizontally or at 1/8 of the circumference. This system will reduce the possibility that the meter would measure volumes of air.

The T-piece no. 10 in the above figure is suggesting that similar arrangement to the one composed of items 11 through 15 should be repeated for multi-stories buildings where no convention for a single bulk meter exists.

In case one single connection is to be installed, with reference to the above figure, the nipple 11 shall be joined to the union piece 6.

The shown configuration is recommended for the situation when the meter can be located in-house. If this is not possible, the meter shall be provided with housing (box or chamber).

All materials of pipes, fittings, and any appurtenances are to be adapted to the technical specifications.

13. PROPOSED IMPLIMENTATION STRATEGY

13.1. TYPE OF IMPLEMENTATION CONTRACT

Traditional contract type used for pipe laying works is the Pink Book FIDIC contract where the detailed design including the Bill of Quantities is prepared by the client and the contractor is only executing the physical works. After the finalization of the works, the beneficiary who has a low capacity and knowledge in operating the system in an efficient way faces all of a sudden following challenges:

- increased need of know-how for operating the modern assets;
- maintaining the level of service according to the finance agreement with the donor;
- unsuitable number and qualification of medium level staff
- unsuitable qualification of the managerial staff;
- rapid deterioration of the new assets due to lack of maintenance funds and due to lack of control on illegal interventions.
- absence of cost recovery making the investment unsustainable

In order to avoid the above bottlenecks the Consultant proposes a Performance Based Implementation Contract. Item rate contract is proposed for this package 01 since all the designs were done by the consultant and the contractor is only executing the work physically as per the items in the BOQ. ADB is a contributor to the development of this document.

The construction works consist of:

- Refurbishment of the Production Capacities;
- Construction of Network and storage capacities,
- Works execution DMA wise (including OHT, Raising Mains and Monitoring Stations);

The Operation Activities consist of:

- Operation of the finalized DMAs
- Operation of the entire System for a period of 4 years after the end of construction works;
- Capacity Building of the Operations section of GMC to be formed during the construction period.

A item wise fees, performance or incentive payments, and payments for materials and civil works shall be used. The payments are proposed to be effected according to the structure described below:

(A) For the Construction Period

- 70% of the works completed in the respective DMA based on Unit Rates for supply and installation for pipe laying and other civil works.
- 20% of the works completed in the respective DMA, after the completion of the entire DMA, based on Unit Rates for supply and installation for pipe laying and other civil works after submitting evidence of meeting the performance criteria.
- 10% of the works completed in the respective DMA based on Unit Rates for supply and installation for pipe laying and other civil works after submitting evidence that all existing pipes not to be used in the particular DMA have been decommissioned. In case there are no pipes to be decommissioned, the contractor will submit evidence documents substantiating the payment of the 10%.

(B) For the Operation Period

- One fixed Monthly Fee portion
- One portion based on meeting the Performance Criteria

The performance component of the payment to the contractor is described below in the Section 13.5. These criteria are divided in:

- Operation during Physical Implementation
- Operation after the finalization of the Physical Implementation.

The operation during the execution of works for the finalized DMAs shall have as purpose the substantiation of the difference of 20% payment as mentioned under (A) above.

Due to the fact the contractor will be required to implement the works DMA wise, the operation of the finalised DMAs is to be taken up immediately thereafter. This period is ideal for gradually selecting and integrating the staff of the Operations Unit of GMC in the own team.

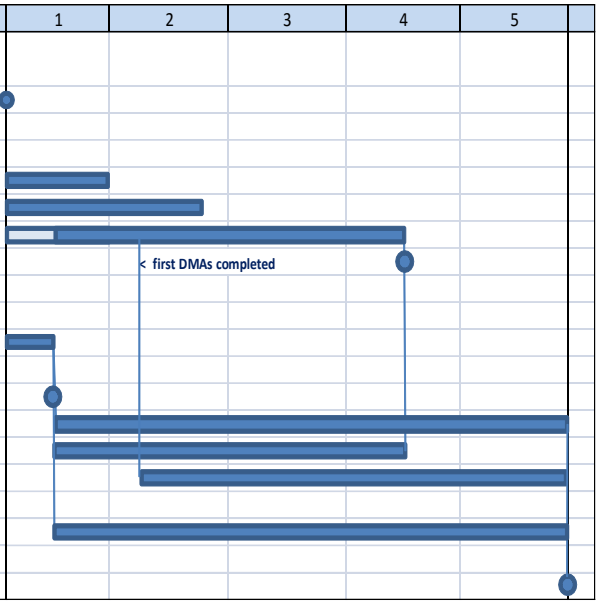
For the reasons described above, the expected Bidders/Contractor shall be qualified Joint Venture of Construction Companies and Operators of Water Utilities.

13.2. SEQUENCING OF WORKS

The proposed sequence of the works implementation under Gaya Water Supply Project is as given in the Figure 13-1 below:

Figure 13-1: Proposed Schedule of Implementation

Description	duration months	end date month
Contract Commencement Date		
Part 1 Works		
- Section 1: Water Source Works	12	12
- Section 2: Transmission Mains and Storage Reservoirs	21	21
- Section 3: DMA Construction Works	42	42
completion of all Works		**42**
Part 2 Operations		
Operations preparation period	6	6
Operation Service		
Start of Operation Period	6	6
- Subpart 4: Operation of existing water sources and transmission	54	60
- Subpart 5: Operation of existing distribution network	36	42
- Subpart 6: Operation of DMAs in which Works have been completed	45	60
Training		
- Subpart 7	54	60
Contract Completion Date		**60**



13.3. FORMING THE DMAS

The main activity of this water supply project is the operation of 30 DMAs covering the entire town. Based on an updated distribution network drawing and hydraulic models, DMAs for the entire town have been proposed.

After the successful execution of the works described below for establishing and operating the DMAs, the actual operation of the DMAs is possible. The anticipated works will consist of, but not limited to, the following:

(i) detailed site investigations, updating of distribution network drawings, complete with all trial holes that might be required to verify pipe connections

(ii) hydraulic modelling as basis for optimum DMA design and determination of feeder main diameter

(iii) verification of suggested DMA boundaries

(iv) locating existing boundary valves, functioning and tightness checks of existing boundary valves, identification of location for additional boundary valves to be installed, identification of locations where the pipes will be disconnected and capped

(v) selection and marking of location for DMA inflow monitoring station

(vi) Identification and GPS registration of customer service connections that have to be re-located from a trunk or distribution main outside the DMA (or in a neighbouring DMA) to a distribution main inside the DMA. Only for pipelines laid in 1982 the old service connections will be replaced by new ones.

(vii) Identification and GPS registration of customer service connections that have to be re-located from a trunk or distribution main outside the DMA (or in a neighbouring DMA) to a distribution main inside the DMA for newly laid pipelines.

(viii) Decommissioning of all the pipes to be replaced as above.

(ix) site survey for DMA inflow point and location of underground assets

(x) If hydraulically possible, DMAs should be single feed. In cases where it is advisable (for hydraulic or other reasons) to establish multiple feed DMAs additional DMA inflow monitoring station will be provided.

(xi) Designing and detailing of:

- (a) all pipelines that have to be laid
- (b) location and installation details of new boundaries valves
- (c) DMA inflow point arrangement design, pressure reducing valve chambers complete with all pipe works and structural design
- (d) inflow meter and PRV specifications; location and design of above ground instrumentation box
- (e) standard design and map with location of all customer connections to be relocated
- (f) all other civil, mechanical, installation or plumbing works that might be required

(xii) construction of PRV chamber, underground installation of electromagnetic flow meter, construction of above ground instrumentation box; including supply of all required pipes, materials, fittings and equipment, as per the specifications

(xiii) Installation of multiple/single channel data logger (two pressure and one flow channel) at the inflow point, setting up of data transfer to a central server (SMS, GPRS or similar data transfer; installation of respective software.

(xiv) construction of the critical point above ground instrumentation box; including supply of all required materials, fittings and equipment, as per the specifications

(xv) execution of all other civil, mechanical, installation or plumbing works, including supply of all required pipes, materials, fittings and equipment required for DMA establishment

(xvi) restoration of roads and footpath surfaces

(xvii) execution of zero-pressure test and execution of all subsequent investigations and works should the first zero-pressure-test have failed until the test is successfully performed

(xviii) commissioning of PRV and controller

(xix) preparation of as-built drawings for all works executed, updating of all electronic mapping system

(xx) any other unforeseen works, if required, to make whole system operational

13.4. SERVICE CONNECTIONS

Replacement of leaking service connection pipes, providing new consumer service connections, domestic meter Installation and unforeseen works are not included in DMA Establishment described above.

The disinfected water will be supplied from the water main to the individual houses through a house service connection only through tapping by ferrule by authorized plumbers. This consists of two parts, i.e. communication pipe, which runs from the street main to the boundary of the premises and the service pipe, which runs inside the premises. The consumer will be responsible for the laying of pipes beyond these lines and for the purchase and installation of water meters.

For multi flats building one main metered connection (one service contract) will be granted for the whole building in case it will not be possible to sign contracts with each consumer separately.

In particular the works involved for providing the service connections will be:

(a) detailed design,

(b) installation of service connections for new customers, complete with all fittings,

(c) conditional check of existing service connections and replacement of entire connection including pipe saddle, if required

(d) restoration of road or footpath surface

(e) GPS coordinates will be registered in GIS system while providing the service connections to the consumers and updated on electronic mapping system

(f) installation of Class B customers meters for all customers, complete with all fittings

(g) Providing a meter box inside the premises of the consumer and any other unforeseen works, if required, to make whole system operational

13.5. FUTURE OPERATION OF THE SYSTEM

The contractor is expected to fulfil all the tasks that are given in sub section 13.5.1 “Description of Services” below. However his performance would be assessed by those parameters that are easily measurable like report submissions and training programmes and by those that indicate the achievement of overall project objectives. As stated above the main objective of this project are to provide uninterrupted (24x7) supply of water at certain pressure to customers, introduce modern management information and customer service, significantly reduce operating costs, in particular energy costs; reduce non-revenue water and improve revenue collection.

Following eight performance parameters were selected to form the indicators of project objectives:

9) Connections converted for 24x7 water supply system;

10) Reducing / maintaining low level of Non-Revenue Water;

11) Reducing energy consumption;

12) Maintaining water quality;

13) Maintaining terminal pressure in the distribution system;

14) Increasing revenue collection efficiency;

15) Customer complaint handling;

16) Development of Plans and Programs.

The above eight parameters will be given more weight compared to other parameters in the performance measuring system to highlight importance of these parameters in attaining the overall goal of the project.

13.5.1. DESCRIPTION OF SERVICES TO BE PROVIDED BY THE OPERATOR

(1) The Operator shall:

a. Operate the Facilities to carry out:

(i) The pumping and transportation of water from ground water wells and reservoirs

(ii) The disinfection and treatment of water where necessary; and

(iii) The distribution and supply of water to the Customers;

b. Maintain the Facilities and develop comprehensive maintenance management programs for the Facilities;

c. Develop and manage programs to train and advance the skills of persons supervised by the Operator, inclusive staff of GWB;

d. Carry out all billings, collections and Customer relations and service functions related to the Customers in the Service Areas with respect to water services;

e. Except as provided otherwise in the Contract, carry out all management, financial and administrative responsibilities related to the GMC'S Water Supply Utility;

f. Plan and manage the implementation of programs carried out under a Preventive Maintenance Fund to be created; and

as set out in this Description of Services.

(2) Except as otherwise provided, the Operator shall provide the Services to all DMAs.

13.5.2. GENERAL PROVISIONS

Following General Provisions will be applicable to Plans, Programs, Reports, Surveys, and Guidelines. In accordance with this Description of Services, the Operator shall, in addition to its other responsibilities, develop the following documents:

(1) Progress Reports

(2) Base Year Data Report and Operation and Maintenance Plan;

(3) Management Information Systems Plans;

(4) Procurement Guidelines;

(5) Strategic Business Plan;

(6) Emergency Response Plan;

(7) Staff Training and Development Program and Merit Payment Program;

(8) Water Quality Sampling and Testing Program;

(9) Safety Deficiencies Correction Plan;

(10) Occupational Health and Safety Program;

(11) Inventory Management Program;

(12) Standard Operating Procedures;

(13) Operations and Maintenance Manuals;

(14) Maintenance Management Programs;

(15) Annual Preventive Maintenance and Extensions Fund;

(16) Facilities Data Base and Initial Condition Survey;

(17) Network Information System Plan;

(18) Financial Management and Customer Service Information Systems Plan;

(19) Commercial Management Plan;

(20) Customer Service Plan;

(21) Customer Service Training Program;

(22) Public Awareness Program;

(23) Final Condition Survey;

(24) Final Transition Plan.

14. DESIGN PARAMETERS AND CRITERIA

14.1. KEY TARGETS AND PLANNING HORIZONS

As suggested by the ADB key targets for the cities of Bihar under the investment program by 2021 are:

(i) Water supply coverage at 95% of the population;

(ii) Water supply quantity at 135 litres per capita per day;

(iii) Water supply duration for 24 hours on 7 days per week;

(iv) Non Revenue (NRW) water at less than 20% of the total water produced;

Additional targets referring to wastewater and solid waste do not apply to this project.

The starting of the capital works is foreseen for 2014 and their finalisation for 2018. The design life of the pipelines supposed to be in place by the end of the project is of 30 years. Therefore the target year is 2048 and the intermediary stages considered in our projections are as following:

- Stage 1 of projections - year 2014 to 2018;
- Stage 2 of projections – year 2021 for meeting the agreement between ADB and GOB;
- Stage 3 of projections – year 2033 for the verification of intermediary results;
- Stage 4 of projections – year 2048 for meeting the useful life of the assets.

14.2. TECHNICAL LEGISLATION

The proposals are intended to harmonise water facilities with the requirements of directives whenever applicable. Key legislation for planning purposes is as follows:

- The Water (Prevention and Control of Pollution) Cess (Amendment) Act, 1974, amended in 2003
- The Environment (Protection) Act, 1986, amended in 1991
- National Water Policy 2012
- National Urban Sanitation Policy (2008)
- National Water Framework Act, 2013
- River Board Act, 1956
- 74th Constitutional amendment Act and Guidelines issued by JNNURM for urban water supply systems

14.3. WATER DEMAND

The projected water demands in years 2013 till 2048 are assessed for each ward according to the information and procedures set out below, and the situation for intermediate years being also shown.

14.3.1. DOMESTIC DEMAND

Based on the impacts of metering and introduction of tariffs, the design criteria regarding the water demand for various categories of consumers are as follows:

Description	*l/c/d*
Domestic Per Capita Fully Plumbed	135
Floating Population	70
Domestic Per Capita Public Stand Post	50

The specific domestic consumption indicated in CPHEEO manual indicates 135 l/d per capita for population living in urban areas with water born sewerage systems in place or under preparation or stipulated.

The introduction of cost covering tariffs will result in lower water demand that is limited to human requirements. Agricultural water application will continue to be satisfied from local water sources.

Networks are to be designed for the FP house connection demand assuming the maximum future demand.

14.3.2. INDUSTRIAL DEMAND

Non-domestic wastewater flow-rates from industrial sources vary with the type and the size of the facility, the degree of water reuse, and the onsite wastewater treatment methods if any.

The present occupation of industrially used land is widely unclear. The water consumption was therefore linked to estimates by Gaya Municipal Corporation. The only known industries are power looms, dyeing and milk production.

The milk collection and commercial production is located in the ward No. 26 and its production is of 35000 l milk per day.

The water demand considered was the one recommended in the technical literature for this type of industry, which is 2 l water / l milk, resulting in 70000 l/d.

The dyeing industries were estimated to consume between 500 l/d and 1000 l/d. Therefore a median value of 7500 l/d was considered. The number and location of the dyeing industries is presented below:

Ward	*No of industries*	*Demand in l/d*
47	*200*	*150000*
50	*1000*	*750000*
51	*1200*	*900000*

14.3.3. INSTITUTIONAL AND COMMERCIAL DEMAND

This refers to the water demand of facilities such as schools, hospitals, hostels for floating population, etc.

The demand estimation is generally based on figures recommended in the technical literature. The daily demand for major users was based on the following criteria:

Description of Demand	*l/c/d*
Hospital each Bed + Staff	350
School: each Pupil + Teacher & Staff	50
Hostel for Floating Population: each guest + staff	70

The figures referring to the location and capacities of the above type of demands were obtained from each ward council.

14.3.4. LIVESTOCK DEMAND

Livestock demand in Gaya is considerable and detailed number for each kind of animal ward wise were obtained from the wards councils.

Type of animals	*l/c/d*
Large animals Horse/Cow/Buffalo	40
Small animals Sheep/Goats/Pig	4

14.3.5. FIRE FIGHTING

It is assumed that, requirements for fire fighting will be accommodated in the normal allowances for source capacity, storage, and transmission and distribution systems. Detailed designs incorporate the requirements of 20 l/s for 3 consecutive hours.

14.3.6. NON-REVENUE WATER (NRW)

Non-revenue water (NRW) is expressed as a percentage of the total water produced for the system. NRW includes system leakage, water taken by illegal connections, inaccuracies in metering, overflowing of reservoirs and legitimate un-metered use such as fire fighting, flushing, etc. In the absence of metering and more detailed information on present losses and the systems, it is estimated that NRW (and water losses in 2013) are function of the number of connections.

By implementing the project, a large part of the distribution network and consumers connections will be replaced by 2018. For this reason the specific value for NRW was considered to be the lowest by 2018 and slightly increasing until the year 2048.

A certain proportion of water losses in the systems are unavoidable even if the systems are new. The used figures for calculating the losses and future NRW demand is as following:

Specific Water Loss or NRW by stage of projection	*[l/conn/day]*
Water Loss 2013	700
NRW 2018	150
NRW 2021	160
NRW 2033	170
NRW 2048	200

The NRW specific values resulting from indicators extracted from various utilities around the globe are as following:

Description	*NRW in litres connection and day*
System in perfect condition	< 100
System in good condition	100 – 250
System in average condition	250 – 450
System in bad condition	>450

The present project aims at implementing the operation of the system by the contractor, paid based on the performance in maintaining a good condition of the system. After the period of operation by the contractor and introduction of tariffs, the establishment of a municipal operator fully trained and applying commercial principles is foreseen. All consumers' connections will be metered and the DMAs with flow and pressure monitoring equipment will be installed. The operator will be equipped with all necessary tools and no reason for not maintaining the system in good working condition is anticipated.

14.3.7. DEMAND VARIATIONS

Seasonal and daily peak factors will be adopted for the design of water and wastewater facilities. For the purpose of assessing the required capacity the following factors are applied:

Town	Daily flow peak "k day"
Gaya	2

14.4. WATER LOSSES

Following method of calculating the water losses depending on the diameter of the hole in the system component (reservoir or pipe) shall be used:

Hole diameter (mm)	*Litres per minute*	*Hole diameter (mm)*	*Litres per minute*
0.5	0.33	4	14.8
1	0.97	4.5	18.2
1.5	1.82	5	22.3
1.8	2.5	5.5	26
2	3.16	6	30
2.5	5.09	6.5	34
3	8.15	7	39.3
3.5	11.3		

The above figures correspond to a pressure of 5 bar. If the pressure differs, following correction factors shall be applied:

Pressure	*Factor*
4 bar	0.89
3 bar	0.77
2 bar	0.68
1 bar	0.45

14.5. TYPES OF CONNECTIONS

It is the target of the project to provide 95% of the population of Gaya in the year 2021 with fully plumbed connection and 135 l/c/d for 24 hours during 7 days of the week. The present situation shows that only 45% of the inhabitants are fully plumbed and 10% are served by Public Stand Posts. We have proposed a gradual migration of the consumers from one type of connection to the other as following:

Projection of Migration of Type of Consumers [%]		
Year	*Fully Plumbed*	*Public Stand Post*
2013	45%	10%
2018	87%	8%
2021	**95%**	**4%**
2033	96%	2%
2048	98%	1%

As mentioned above the urban development is not known at the present stage and the future configuration of the streets in Gaya until the year 2048 cannot be anticipated. For this reason it is reasonable to assume that migration from outside Gaya will continuously occur and the threshold of 100% of inhabitants connected will not be achieved.

14.6. STORAGE CAPACITIES

Operational reservoirs (OHTs) should have sufficient storage to cover the difference between hourly peak demand and actual supply from the source, firefighting demands, and for an emergency volume in case of power breakdown, repairs or O&M activities. In general about six to eight hours supply will be sufficient for balancing storage in the town. Additional emergency storage will depend on the level of risk to the supply.

In order to provide for security of supplies above the need for balancing purposes it is recommended that the minimum storage capacity be in the range of 25% of the average daily demand.

Recommendation:

Tank/Reservoir Design Parameters vs. Function	*Volume*
Primary Transmission	4 hours of the total crossing flow
Distribution (Terminal)	12 hours of 15% average flow
Pumping Station	2 hours of pumping volume

In the case of Gaya the Primary Transmission Reservoirs and the Distribution OHTs are the same. As result the above capacities were added.

14.6.1. SERVICE RESERVOIR DESIGN

- Useable storage capacity to be determined allowing for - 150 mm freeboard for GLSRs and 500 mm for OHTs, 300 mm minimum floor cover and a safety factor of 1.3 against outlet flow vortex effects;
- Baffle walls will be provided inside the tank compartments for rectangular tanks with a capacity greater than 1000 m^3;
- An overflow chamber will be provided in each tank compartment;
- Inflows to the tank will be controlled by two isolation valves that will be installed on either

side of the float operated valve;

- The outlet bell-mouth will be installed in sumps in the floors of each tank compartment;
- Access to each compartment of the reservoir should be provided at two (2) locations in the roof slab;
- Access ladders will be installed internally at each access point and one location externally;
- Air Vents;
- Distance of erection with respect to other public assets:
- 20 m to roads and buildings
- 50 m to industrial devices and buildings, wastewater collectors, toilets, livestock sheds, etc.
- 200 m from any potential source of infection.

14.7. PIPE WORK

14.7.1. PIPELINES AND NETWORK DENSITY

Transmission mains from well field to reservoir should be designed for the maximum daily demand. Storage facilities at the termination of the transmission main should cater for the peak hourly flow in the distribution system. The distribution network will be designed for the peak hourly demand mentioned earlier. Water velocities shall be maintained at less than 2 m/sec. The recommended materials are: PE, HDPE, DI,

The ceiling density of the network adopted for the outer wards where the urban development is not yet completed was chosen based on the density of the proposed network in ward 26 in the frame of the present design to be completed by 2018.

Distribution network target density m/capita connected	*length [m]*	*Pop2018*	*m/cap. Connected*	*m/tot. no. of connections*
Ward 26 in 2018 considered as saturated in terms of m/capita	12113	7561	1.6	12.25

The above figures were used as guidance for calculating the level of service in terms of length of distribution network at the respective projection targets in the marginal wards. However the density figures were adapted in time steps according to the projection years according to the resulting total length of network to be laid.

14.7.2. ALLOWABLE FLOW VELOCITIES AND HEAD LOSS

Inside Diameter mm	Velocity m/s	Flow m^3/h	Head loss m/km
100	0.8	22.6	6.3
150	0.9	54.1	4.9
200	0.9	101.8	5.3
250	1	167.9	4.95
300	1	254.5	4
400	1.1	497.6	3.4
500	1.2	848.2	3.1
600	1.3	1323.2	2.9

For Pumping Station Pipes:

- Velocity in suction pipe less than 1.6 m/s
- Velocity in delivery pipe less than 3 m/s

14.7.3. STANDBY CAPACITIES

Boreholes are to be provided with a power source, which is reliable. Booster and pumping stations are to be provided with both pumping capacity standby and power source standby, as follows:

- Minimum 50% stand by pump sets shall be provided but in exceptional cases stand by pump sets up to 100% may be provided.

14.7.4. FRICTION FACTORS

Below factors refer to Hazen-Williams formula.

Pipe - links	Material	Roughness
Asbestos Cement	AC	130
Cast Iron, unlined	CI	110
Concrete	CO	120
Ductile Iron	DI	140
Galvanized Iron - Steel	GI	120
Glass Reinforced Pipe	GRP	130
High-Density Polyethylene	HDPE	145
Polyethylene	PE	140
Polyvinyl Chloride	PVC	140
Reinforced Concrete	RC	120
Steel Mild Unlined	St	110

FITTING	LOSS COEFFICIENT
Globe valve, fully open	10
Angle valve, fully open	5
Swing check valve, fully open	2.5
Gate valve, fully open	0.2
Short-radius elbow	0.9
Medium-radius elbow	0.8
Long-radius elbow	0.6
45 degree elbow	0.4
Closed return bend	2.2
Standard tee - flow through run	0.6
Standard tee - flow through branch	1.8

FITTING	LOSS COEFFICIENT
Square entrance	0.5
Exit	1

14.8. METERING

14.8.1. CONSUMERS' SERVICE CONNECTIONS

It is assumed that in future all consumers will be metered. The consumer water meters shall be of inferential type, magnetically driven and conforming to IS779 and ISO4064.

14.8.2. DISTRICT METERED AREAS

In the District Metered Areas, the pressure shall not be less than 1.2 bar and should not exceed 3 bar. Pressure is either controlled by the topography or pressure reducing valves.

Distribution Mains distribute water within the DMA.

It is recommended the DMA design to respect to the following criteria:

- Provided with EM District Meter;
- Pressure, minimum 1.2 bar, maximum 3 bar;
- Pressure Reducing Valves are to be used where pressure reduction is necessary;
- No consumer connection pipe should cross a district boundary;
- If a boundary is in the middle of the road the main needs to be on the side of the road of the district to which it belongs, or the boundary should be behind the line of houses;
- Provided with up to 3 Flow-Pressure Monitoring Stations including protection encasement and equipped for Data Logging and connecting to a SCADA system;
- Monitoring stations and meters to be installed at safe location onto the sidewalk where possible. Optionally provision for GSM automatic reading can be made;
- High areas provided (preferably) with variable speed pumps or elevated tanks;
- Contain up to 8,000 metered service connections in 2048.
- Sufficient number of valves for future operation will be provided in such a way to enable 4 or 5 steps for the Step Test.

14.9. ELECTRO-MECHANICAL EQUIPMENT

14.9.1. HYDRAULIC CRITERIA FOR PUMPS

- Suction velocity in the order of 1.6 m/s
- Pump discharge in the order of 3 m/s
- General isolating suction valve in the case of a station composed of several pumps with positive suction conditions.
- Non return valve for the delivery of each pump
- Isolation valve for each pump discharge (possible butterfly)
- Delivery manometer (possibly with electrical contacts)

- Dismantling joints necessary for proper maintenance
- General delivery collector with butterfly isolating valve
- Volumetric counter with pulse head (to calculate the flow)
- Protection device against transitory phenomena, wherever appropriate
- Washouts for flushing and cleaning of the rising pipelines will be provided at each pumping station

14.9.2. REGULATION AND MONITORING

The above described zoning would allow more efficient management of the network. All systems will be supplied by gravity or pumping, and metered, allowing the Operator to manage the distribution of water. District flow meters and customer billing will allow measurement of Non Revenue Water.

In addition, the normal decreasing efficiency of the network will be monitored allowing the necessary intervention to rehabilitate the distribution network to be prioritised and programmed efficiently and effectively.

The reservoirs will be equipped with an altitude valve and a float operated valve, reducing risk of overflowing and wastage.

Distribution flow meters, are to be installed at Reservoirs. Comparison of Distribution to District meters will allow calculation of detailed water balance and estimation of leakage in the secondary distribution pipes.

- All monitoring equipment to be suitable for later optional incorporation as a part of a SCADA system;
- Reservoirs: level metering;
- Pipelines: flow and pressure metering;
- All Bulk Water Meters to be of EM/Mechanical type and suitable for data logging;
- Multiple channel (minimum 2) Data Loggers;
- Provision of GSM reading to be investigated at the detailed design stage;
- Monitoring Stations and Valves to be marked and recorded in a data base along with their GPS coordinates.

14.10. COSTS

Depreciation:	20%.
Interest:	40%.
Personnel:	13%.
Energy, and other miscellaneous O+M cost:	27%.

15. DESIGNS

15.1. POPULATION PROJECTIONS

The development of a town depends upon natural, physical and socio-economic factors. Among these factors, the population assumes significance in determining the future pattern of progress and development.

Gaya is expected to undergo many changes in its economy and demography in the coming years. The continuous exodus of rural population to urban areas has contributed to the exponential growth resulting in severe strain on the existing infrastructure. There has been considerable increase in developmental activities, which is causing a growth in urbanization. In addition to the resident population a good number of tourists flock to Gaya for religious reasons.

The design population is estimated with due regard to all factors governing the future growth and development of the project area in the industrial, commercial, educational, social and administrative spheres. Special factors causing sudden migration or influx of population has also been foreseen to the extent possible.

The forecasted population of Gaya is arrived at based on the methods laid down in the Manual on Water Supply and Treatment, published by the Ministry of Urban Development, Govt. of India, which are as follows:

- Arithmetical increase method
- Geometrical increase method
- Incremental increase method
- Exponential graphical method
- Linear increase graphical method
- Decadal growth increase method

The population projection has been carried out for 30 years from year 2018 to 2048. The base year for works identified and designed under this project has been considered as 2018. Detailed population projections by various methods are therefore made for the base year 2018, mid-design year 2033 and design year 2048, which is presented as follows:

Table 24: Population projections by various methods

Population projection for the years 2018, 2033 & 2048 based on census data from year 1921 to 2011			
Census Population for year 1961 to 2001			
Year	**Census population**	**Increment X**	**Increment Y**
1921	67,562		
1931	88,005	20,443	
1941	1,05,223	17,218	3,225
1951	1,33,700	28,477	11,259
1961	1,51,105	17,405	11,072
1971	1,79,884	28,779	11,374
1981	2,47,075	67,191	38,412
1991	2,91,675	44,600	22,591
2001	3,89,192	97,517	52,917

2011	4,68,614	79,422	18,095
	Average	**44,561**	**7,372**
1. Arithmetic increase method			
Increase per decade			44,561
	Pop. in n^{th} year	=Pop. in $(n-1)^{th}$ decade + Increase for n decade	Projected Pop.
Population in 2011 based on 2001			4,33,753
Population in 2018 based on 2011			4,99,807
Population in 2033 based on 2011			5,66,649
Population in 2048 based on 2011			6,33,491
2. Geometrical increase method			**rg**
Rate of growth (r) between 1931 & 1921			0.3026
Rate of growth (r) between 1941 & 1931			0.1956
Rate of growth (r) between 1951 & 1941			0.2706
Rate of growth (r) between 1961 & 1951			0.1302
Rate of growth (r) between 1971 & 1961			0.1905
Rate of growth (r) between 1981 & 1971			0.3735
Rate of growth (r) between 1991 & 1981			0.1805
Rate of growth (r) between 2001 & 1991			0.3343
Rate of growth (r) between 2011 & 2001			0.2041
Rg=	Geometric mean	=power(product (rg),1/n))	0.2304
Pop. in nth year		=Pop.in $(n-1)^{th}$ year*power((1+rg),n)	**Projected Population**
Population in 2011 based on 2001			4,78,850
Population in 2018 based on 2011			5,41,801
Population in 2033 based on 2011			7,39,424
Population in 2048 based on 2011			10,09,129
3. Incremental increase method			
Pop. in n^{th} year		=Pop.in $(n-1)^{th}$ year +n*X+(n(n+1)*Y)/2	**Projected Population.**
Population in 2011 based on 2001			4,41,126
Population in 2018 based on 2011			5,04,193
Population in 2033 based on 2011			5,92,600
Population in 2048 based on 2011			6,97,592

4. Exponential Graphical Method			
Year	**X-axis Years**	**Census Population**	**Interpolated population 2nd degree**
1921	0	67,562	80,245
1931	10	88,005	83,140
1941	20	1,05,223	95,945
1951	30	1,33,700	1,18,662
1961	40	1,51,105	1,51,290
1971	50	1,79,884	1,93,830
1981	60	2,47,075	2,46,280
1991	70	2,91,675	3,08,642
2001	80	3,89,192	3,80,915
2011	90	4,68,614	4,63,099
2018	97		5,24,297
2033	112		6,75,237
2048	127		8,48,200
5. Linear Graphical Method			
Year	**X-axis Years**	**Census Population**	**Projected Population.**
1921	0	67562	20,778
1931	10	88005	63,317
1941	20	105223	1,05,856
1951	30	133700	1,48,395
1961	40	151105	1,90,934
1971	50	179884	2,33,473
1981	60	247075	2,76,012
1991	70	291675	3,18,551
2001	80	389192	3,61,090
2011	90	468614	4,03,629
2018	97		4,33,406
2033	112		4,97,215
2048	127		5,61,023
6. Decadal growth rate method			
Census Year	**Census Population**	**Decadal Increase**	**Decadal Growth Rate in %**
1921	67562		
1931	88005	20443	30.26
1941	105223	17218	19.56
1951	133700	28477	27.06

1961	151105	17405	13.02
1971	179884	28779	19.05
1981	247075	67191	37.35
1991	291675	44600	18.05
2001	389192	97517	33.43
2011	468614	79422	20.41
Total		401052	
Average		44561	
Average			**24.2**
S. No.	**Year**	**Population**	**Projected Population.**
1	1921	67562	
2	1931	88005	
3	1941	105223	
4	1951	133700	
5	1961	151105	
6	1971	179884	
7	1981	247075	
8	1991	291675	
9	2001	389192	
10	2011	468614	483532
11	2018		548128
13	2033		718516
14	2048		888905

The census population for 2011 is available as an authentic basis for comparison. Therefore, the projected populations carried out by various methods for Year 2011 have been cross checked with the census population of 2011, which is given in the Table 25 below:

Table 25: Variation comparison by various methods

No.	Population Projection Method	Projected Population	Census Population	Variation
		2011	2011	%
1	Arithmetic Increase Method	4,33,753	4,68,614	7.44
2	Geometric Increase Method	4,78,850	4,68,614	-2.18
3	Incremental Increase Method	4,41,126	4,68,614	5.87
4	**Exponential Graphical Method**	**4,63,099**	**4,68,614**	**1.18**
5	Linear Increase Graphical Method	4,03,629	4,68,614	13.87
6	Decadal growth increase	4,83,532	4,68,614	-3.18

It is evident from the table above that the percentage variation of population projected by Exponential Graphical Method is the least (1.18) as compared to that by other methods. Therefore Exponential Graphical Method has been recommended and used for water demand assessments for Gaya. The projected population for Gaya, therefore, is as follows:

Horizon Years	Projected Population
Base Year (2018)	5,24,297
Mid-Design Year (2033)	6,75,237
Design Year (2048)	8,48,200

15.1.1. WARD WISE POPULATION PROJECTIONS

Under jurisdiction of Gaya Municipal Corporation there are 53 municipal wards. The ward wise population projections are shown below.

Table 26: Ward wise population projections

Ward No.	Population as per Census		% of population growth	Area in Ha	Projected population			
	2001	2011			2018	2021	2033	2048
1	6901	9398	36.18	239.5	10515	11591	13542	17579
2	8020	8264	3.04	54.8	8755	9006	11417	14467
3	6564	12881	96.24	46.6	19280	21571	24831	31191
4	6638	13015	96.07	65.7	14562	15351	18754	23557
5	7587	3734	-50.78	69.8	4178	4404	5380	6759
6	6884	13776	100.12	74.6	14594	15012	19032	24116
7	7939	8676	9.28	13.4	9191	9455	11986	12854
8	7939	10714	34.95	17	11987	12637	15438	16597
9	6610	5741	-13.15	15.5	6082	6256	7931	10050
10	6900	8219	19.12	15.4	8707	8957	11355	14388
11	7201	6779	-5.86	11.9	7182	7387	9365	11811
12	7740	10526	35.99	17.6	11151	11471	14542	17319
13	6861	4134	-39.75	16.9	4380	4505	5711	7237
14	7445	10474	40.69	26.8	11096	11414	14470	18336
15	7343	7279	-0.87	13.6	7711	7932	10056	12743
16	7765	6901	-11.13	11.9	7311	7520	9534	12081
17	6948	6422	-7.57	15.9	6804	6998	8872	11242
18	6475	4365	-32.59	6.4	4624	4757	6030	6484
19	6756	5139	-23.93	12.7	5444	5600	7100	8996
20	6401	4576	-28.51	12.9	4848	4987	6322	8011
21	7251	2700	-62.76	5	2860	2946	3730	4727
22	6510	8869	36.24	19.6	9396	9665	12253	15526
23	6770	7187	6.16	37.1	7614	7832	9929	12582
24	7291	6636	-8.98	29.7	7030	7232	9168	11617
25	6672	10346	55.07	51.2	10961	11274	14293	18112
26	7034	7003	-0.44	39.6	7419	7631	9675	12259
27	6608	15984	141.89	50.2	16934	17418	22082	27982
28	7873	10663	35.44	61.3	11930	12577	15365	19300
29	7392	8407	13.73	900.2	13357	16029	18005	27612
30	7989	15981	100.04	223.9	17880	18849	23027	28926
31	7002	8804	25.74	75.6	9327	9594	12163	15412
32	7973	7402	-7.16	113.1	7645	8307	8981	10553
33	7364	5195	-29.45	25.1	5504	5661	7177	9094
34	8089	10865	34.32	37.9	11511	11840	15010	19020
35	8097	4990	-38.37	13.7	5286	5438	6894	8736
36	6962	12581	80.71	56.1	13328	13710	17381	22024

Ward No.	Population as per Census		% of population growth	Area in Ha	Projected population			
	2001	2011			2018	2021	2033	2048
37	7309	3678	-49.68	20.5	3897	4008	5081	6439
38	7192	10574	47.02	12.5	11202	11382	11632	12195
39	7772	5535	-28.78	14.7	5864	6032	7647	9690
40	8154	8584	5.27	23	9094	9354	11859	15027
41	6533	6747	3.28	33.5	7148	7317	9321	11811
42	7960	7399	-7.05	29.5	7839	8063	10222	12953
43	7009	10175	45.17	426.6	11553	12886	14219	18218
44	7467	5800	-22.32	241.2	6145	6878	7827	10199
45	6550	12501	90.85	116	13244	13623	17270	21884
46	6699	9344	39.48	613	10798	12068	13808	17257
47	8265	7974	-3.52	233.6	9408	9867	11014	13957
48	8214	13521	64.61	199.6	16243	17123	20919	26277
49	8305	15482	86.42	51.3	20338	22755	26193	32903
50	8198	15587	90.13	54.3	16513	16986	21534	27287
51	7241	8487	17.21	55.2	8991	9249	11725	14857
52	8240	10972	33.16	92.6	16627	18603	21414	26899
53	8290	11628	40.27	136.4	13010	13715	16755	21047
Total	**389192**	**468614**	**20.41**	**4851.7**	**524297**	**552723**	**675237**	**848200**

15.2. WATER DEMAND CALCULATIONS

Table 27: Detailed ward wise water demand projections

Ward No. YEAR 2048	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Area Year 2048	240	55	47	66	70	75	13	17	16	15	12	18	17	27	14	12	16	6
Population Year 2048	17579	14467	31191	23557	6759	24116	12854	16597	10050	14388	11811	17319	7237	18336	12743	12081	11242	6484
Density [capita/ha]	73.4	264.0	669.3	358.6	96.8	323.3	959.2	976.3	648.4	934.3	992.5	984.0	428.2	684.2	937.0	1015.2	707.1	1013.1
2048 Household	4301	3306	7535	5298	1508	5134	2687	4074	2142	3397	2531	4426	1755	4285	3313	3147	2724	1589
2048 Connected Household	4258	3273	7459	5245	1493	5083	2660	4033	2121	3363	2506	4381	1737	4242	3280	3116	2696	1574
2048 Connected Household [%]	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%
2048 Inhabitants/Household	4	4	4	4	4	5	**5**	4	5	4	5	4	4	4	4	4	4	4
Inhabitants supplied	17403	14322	30879	23322	6691	23875	12725	16431	9950	14244	11693	17146	7165	18152	12615	11960	11130	6419
Inhabitants supplied [%]	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%
Inhabitants Fully Plumbed (FP)	17228	14178	30567	23086	6623	23634	12597	16265	9849	14100	11575	16973	7092	17969	12488	11839	11018	6354
Inhabitants Fully Plumbed [%]	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
Inhabitants Public Stand Post	176	145	312	236	68	241	129	166	101	144	118	173	72	183	127	121	112	65
Inhabitants PSP [%]	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Sp. Demand FP [lpcd]	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
Sp. Demand PSP [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Domestic Demand FP [l/d]	2325726	1913985	4126559	3116643	894164	3190593	1700542	2195812	1329645	1903563	1562575	2291325	957456	2425833	1685854	1598307	1487368	857804
Domestic Demand PSP[l/d]	8790	7234	15595	11779	3379	12058	6427	8299	5025	7194	5905	8660	3619	9168	6371	6040	5621	3242
Domestic Demand [l/d]	2334515	1921219	4142154	3128421	897543	3202651	1706968	2204111	1334670	1910757	1568481	2299985	961074	2435001	1692225	1604348	1492990	861046
Floating Pop. + Service Staff							6000									6000		
Sp. Demand Floating Pop. [lpcd]	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Demand Floating Pop. [l/d]							420000									420000		
Hospital Served Capita												88						176
Sp. Demand Hospital [lpcd]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Demand Hospitals [l/d]												30,746						61,492
2048 Pupils +Teachers	644	966	1208	2013		805	725	322	805		805			805		644	644	805
Sp. Demand School [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Demand Schools [l/d]	32210	48315	60394	100657		40263	36236	16105	40263		40263			40263		32210	32210	40263
Industrial Demand [l/]																		
Livestock Big	1897	1684	567	793	1045	244	49	509	413	1326	1465	91	1119	39	280	220	369	105
Livestock Small	152	141	208	241	545	400	166	290	241	361	334	25	123	51	52	182	114	56
Sp. Demand Livestock Big [l/c/d]	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Sp. Demand Livestock Small [l/c/d]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Demand Livestock Big [l/d]	75880	67360	22680	31720	41800	9760	1960	20360	16520	53040	58600	3640	44760	1560	11200	8800	14760	4200
Demand Livestock Small [l/d]	608	564	832	964	2180	1600	664	1160	964	1444	1336	100	492	204	208	728	456	224
Demand Livestock[l/d]	76488	67924	23512	32684	43980	11360	2624	21520	17484	54484	59936	3740	45252	1764	11408	9528	15216	4424
Fully Plumbed +PSP	4223	3245	7397	5201	1480	5040	2638	4000	2103	3334	2485	4344	1722	4206	3252	3090	2674	1560
Floating p. # Connection							6									6		
Hospitals # Connection												1						1
Schools # Connection	4	6	15	25		10	9	2	5		5			10		4	4	5
Industries # Connection																		

Ward No. YEAR 2048	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2048 Connection #	4,227	3,251	7,412	5,226	1,480	5,050	2,653	4,002	2,108	3,334	2,490	4,345	1,722	4,216	3,252	3,100	2,678	1,566
Sp. Water loss value [l/conn/d]	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Water Loss demand [l/d]	845321	650195	1482306	1045223	296018	1010029	530573	800309	421621	666882	498004	869075	344499	843230	650397	619936	535521	313252
Water Loss demand [MLD]	0.85	0.65	1.48	1.05	0.30	1.01	0.53	0.80	0.42	0.67	0.50	0.87	0.34	0.84	0.65	0.62	0.54	0.31
Water Loss - as [%] of demand	26%	24%	26%	24%	24%	24%	20%	26%	23%	25%	23%	27%	26%	25%	28%	23%	26%	24%
Total Demand [l/d]	3288535	2687653	5708366	4306985	1237541	4264302	2696402	3042045	1814039	2632123	2166684	3203546	1350825	3320257	2354031	2686022	2075937	1280477
Total Demand [MLD]	**3.289**	**2.688**	**5.708**	**4.307**	**1.238**	**4.264**	**2.696**	**3.042**	**1.814**	**2.632**	**2.167**	**3.204**	**1.351**	**3.320**	**2.354**	**2.686**	**2.076**	**1.280**
Served Demand/Capita [l/c/d]	189	188	185	185	185	179	212	185	182	185	185	187	189	183	187	225	187	199
Total Demand [l/s]	**38.06**	**31.11**	**66.07**	**49.85**	**14.32**	**49.36**	**31.21**	**35.21**	**21.00**	**30.46**	**25.08**	**37.08**	**15.63**	**38.43**	**27.25**	**31.09**	**24.03**	**14.82**

Ward No. YEAR 2048	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Area Year 2048	13	13	5	20	37	30	51	40	50	61	900	224	76	113	25	38	14	56
Population Year 2048	8996	8011	4727	15526	12582	11617	18112	12259	27982	19300	27612	28926	15412	10553	9094	19020	8736	22024
Density [capita/ha]	708.4	621.0	945.3	792.1	339.1	391.1	353.7	309.6	557.4	314.8	30.7	129.2	203.9	93.3	362.3	501.9	637.6	392.6
2048 Household	2008	1884	889	3160	2504	2097	3660	2727	6514	3952	7316	6597	3184	2730	2024	3995	1845	4874
2048 Connected Household	1988	1865	880	3129	2479	2076	3624	2699	6449	3912	7243	6531	3152	2703	2004	3955	1827	4825
2048 Connected Household [%]	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%
2048 Inhabitants/Household	4	4	5	5	5	6	5	4	4	5	4	4	5	4	4	5	5	5
Inhabitants supplied	8906	7931	4679	15371	12456	11501	17931	12137	27702	19107	27336	28637	15258	10447	9003	18830	8648	21804
Inhabitants supplied [%]	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%
Inhabitants Fully Plumbed (FP)	8816	7851	4632	15216	12330	11385	17750	12014	27422	18914	27060	28347	15104	10342	8913	18640	8561	21584
Inhabitants Fully Plumbed [%]	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
Inhabitants Public Stand Post	90	80	47	155	126	116	181	123	280	193	276	289	154	106	91	190	87	220
Inhabitants PSP [%]	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Sp. Demand FP [lpcd]	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
Sp. Demand PSP [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Domestic Demand FP [l/d]	1190219	1059825	625334	2054106	1664546	1536932	2396187	1621931	3701977	2553420	3653075	3826897	2039052	1396106	1203189	2516390	1155710	2913825
Domestic Demand PSP[l/d]	4498	4005	2363	7763	6291	5809	9056	6130	13991	9650	13806	14463	7706	5276	4547	9510	4368	11012
Domestic Demand [l/d]	1194717	1063831	627697	2061869	1670837	1542740	2405243	1628061	3715968	2563070	3666881	3841360	2046758	1401382	1207736	2525900	1160078	2924837
Floating Pop. + Service Staff															4800			8400
Sp. Demand Floating Pop. [lpcd]	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Demand Floating Pop. [l/d]															336000			588000
Hospital Served Capita					88													
Sp. Demand Hospital [lpcd]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Demand Hospitals [l/d]					30,746													
2048 Pupils +Teachers	886	483			886			805		805				564	564			
Sp. Demand School [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Demand Schools [l/d]	44289	24158			44289			40263		40263				28184	28184			
Industrial Demand [l/]								70000										

Ward No. YEAR 2048	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Livestock Big	138	291		150	355	591	246	39	739	206	1750	160	395	2066	369	185		369
Livestock Small	97	15		115		193	162	107	881	160	359	397	130	606	366	135	65	89
Sp. Demand Livestock Big [l/c/d]	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Sp. Demand Livestock Small [l/c/d]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Demand Livestock Big [l/d]	5520	11640		6000	14200	23640	9840	1560	29560	8240	70000	6400	15800	82640	14760	7400		14760
Demand Livestock Small [l/d]	388	60		460		772	648	428	3524	640	1436	1588	520	2424	1464	540	260	356
Demand Livestock[l/d]	5908	11700		6460	14200	24412	10488	1988	33084	8880	71436	7988	16320	85064	16224	7940	260	15116
Fully Plumbed +PSP	1971	1850	873	3102	2458	2058	3593	2677	6395	3879	7182	6476	3126	2680	1987	3922	1811	4785
Floating p. # Connection															4			5
Hospitals # Connection					1													
Schools # Connection	11	3			11			10		5				7	7			
Industries # Connection								1										
2048 Connection #	1,982	1,853	873	3,102	2,470	2,058	3,593	2,688	6,395	3,884	7,182	6,476	3,126	2,687	1,998	3,922	1,811	4,790
Sp. Water loss value [l/conn/d]	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Water Loss demand [l/d]	396420	370547	174531	620492	493939	411631	718621	537519	1278984	776888	1436436	1295201	625105	537406	399537	784350	362278	957949
Water Loss demand [MLD]	0.40	0.37	0.17	0.62	0.49	0.41	0.72	0.54	1.28	0.78	1.44	1.30	0.63	0.54	0.40	0.78	0.36	0.96
Water Loss - as [%] of demand	24%	25%	22%	23%	22%	21%	23%	24%	25%	23%	28%	25%	23%	26%	20%	24%	24%	21%
Total Demand [l/d]	1641335	1470236	802229	2688822	2254012	1978783	3134352	2277830	5028036	3389101	5174753	5144550	2688183	2052036	1987681	3318190	1522615	4485902
Total Demand [MLD]	**1.641**	**1.470**	**0.802**	**2.689**	**2.254**	**1.979**	**3.134**	**2.278**	**5.028**	**3.389**	**5.175**	**5.145**	**2.688**	**2.052**	**1.988**	**3.318**	**1.523**	**4.486**
Served Demand/Capita [l/c/d]	184	185	171	175	181	172	175	188	182	177	189	180	176	196	221	176	176	206
Total Demand [l/s]	**19.00**	**17.02**	**9.29**	**31.12**	**26.09**	**22.90**	**36.28**	**26.36**	**58.19**	**39.23**	**59.89**	**59.54**	**31.11**	**23.75**	**23.01**	**38.40**	**17.62**	**51.92**

Ward No. YEAR 2048	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**Total**
Area Year 2048	21	13	15	23	34	30	427	241	116	613	234	200	51	54	55	93	136	4,852
Population Year 2048	6439	12195	9690	15027	11811	12953	18218	10199	21884	17257	13957	26277	32903	27287	14857	26899	21047	848,200
Density [capita/ha]	314.1	975.6	659.2	653.4	352.6	439.1	42.7	42.3	188.7	28.2	59.7	131.6	641.4	502.5	269.2	290.5	154.3	
2048 Household	1532	2538	2293	3008	2570	2845	3776	2171	5081	3775	2934	5395	6165	6357	3299	6122	4432	189,404
2048 Connected Household	1517	2513	2270	2978	2545	2816	3739	2149	5030	3737	2904	5341	6103	6293	3266	6061	4388	187,510
2048 Connected Household [%]	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%
2048 Inhabitants/Household	4	5	4	5	5	5	5	5	4	5	5	5	5	4	5	4	5	4
Inhabitants supplied	6374	12073	9593	14877	11693	12823	18036	10097	21665	17084	13818	26014	32574	27014	14709	26630	20836	839,718
Inhabitants supplied [%]	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%
Inhabitants Fully Plumbed (FP)	6310	11951	9496	14727	11575	12694	17853	9995	21447	16911	13678	25752	32245	26741	14560	26361	20626	831,236
Inhabitants Fully Plumbed [%]	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
Inhabitants Public Stand Post	64	122	97	150	118	130	182	102	219	173	140	263	329	273	149	269	210	8,482
Inhabitants PSP [%]	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Sp. Demand FP [lpcd]	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
Sp. Demand PSP [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Domestic Demand FP [l/d]	851844	1613335	1281935	1988099	1562640	1713647	2410212	1349288	2895296	2283047	1846577	3476474	4353040	3610030	1965633	3558750	2784504	112,216,828

Ward No. YEAR 2048	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	Total
Domestic Demand PSP[l/d]	3219	6097	4845	7514	5906	6476	9109	5099	10942	8628	6979	13139	16451	13643	7429	13450	10523	424,100
Domestic Demand [l/d]	855063	1619432	1286779	1995612	1568546	1720123	2419321	1354388	2906239	2291676	1853556	3489613	4369491	3623673	1973062	3572200	2795028	112,640,928
Floating Pop. + Service Staff	3600	3600	3600	36000	24000				24000									120,000
Sp. Demand Floating Pop. [lpcd]	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Demand Floating Pop. [l/d]	252000	252000	252000	2520000	1680000				1680000									8,400,000
Hospital Served Capita																		351
Sp. Demand Hospital [lpcd]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Demand Hospitals [l/d]																		122,984
2048 Pupils +Teachers					966	644	805			644	805	966	805	644	322	725		23,513
Sp. Demand School [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Demand Schools [l/d]					48315	32210	40263			32210	40263	48315	40263	32210	16105	36236		1,175,672
Industrial Demand [l/]										150000		750000	900000					1,870,000
Livestock Big	201	143	81	340	259	222	239	801	1385	1239	739	585	282	418	220	2255	1046	30,719
Livestock Small	41	16	13	57	58	68	203	340	353	1087	881	266	162	286	91	145	760	12,386
Sp. Demand Livestock Big [l/c/d]	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Sp. Demand Livestock Small [l/c/d]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Demand Livestock Big [l/d]	8040	5720	3240	13600	10360	8880	9560	32040	55400	49560	29560	23400	11280	16720	8800	90200	41840	1,228,760
Demand Livestock Small [l/d]	164	64	52	228	232	272	812	1360	1412	4348	3524	1064	648	1144	364	580	3040	49,544
Demand Livestock[l/d]	8204	5784	3292	13828	10592	9152	10372	33400	56812	53908	33084	24464	11928	17864	9164	90780	44880	1,278,304
Fully Plumbed +PSP	1504	2492	2251	2953	2523	2792	3707	2131	4988	3706	2880	5296	6052	6240	3239	6010	4351	185,932
Floating p. # Connection	5	4	4	15	10				10									69
Hospitals # Connection																		3
Schools # Connection					6	4	5			4	5	6	5	8	2	9		212
Industries # Connection										200		1000	1200					2,401
2048 Connection #	1,509	2,496	2,255	2,968	2,539	2,796	3,712	2,131	4,998	3,910	2,885	6,302	7,257	6,248	3,241	6,019	4,351	188,617
Sp. Water loss value [l/conn/d]	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Water Loss demand [l/d]	301816	499135	450954	593549	507836	559273	742408	426261	999529	782000	576985	1260469	1451302	1249602	648126	1203726	870178	37,723,376
Water Loss demand [MLD]	0.30	0.50	0.45	0.59	0.51	0.56	0.74	0.43	1.00	0.78	0.58	1.26	1.45	1.25	0.65	1.20	0.87	37.72
Water Loss - as [%] of demand	21%	21%	23%	12%	13%	24%	23%	23%	18%	24%	23%	23%	21%	25%	24%	25%	23%	24%
Total Demand [l/d]	1417083	2376351	1993025	5122990	3815289	2320758	3212364	1814049	5642580	3309794	2503887	5572861	6772984	4923349	2646457	4902942	3710085	163211264
Total Demand [MLD]	**1.417**	**2.376**	**1.993**	**5.123**	**3.815**	**2.321**	**3.212**	**1.814**	**5.643**	**3.310**	**2.504**	**5.573**	**6.773**	**4.923**	**2.646**	**4.903**	**3.710**	**163.21**
Served Demand/Capita [l/c/d]	222	197	208	344	326	181	178	180	260	194	181	214	208	182	180	184	178	194
Total Demand [l/s]	**16.40**	**27.50**	**23.07**	**59.29**	**44.16**	**26.86**	**37.18**	**21.00**	**65.31**	**38.31**	**28.98**	**64.50**	**78.39**	**56.98**	**30.63**	**56.75**	**42.94**	**1,889.02**

Ward No. YEAR 2033	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Area Year 2033	240	55	47	66	70	75	13	17	16	15	12	18	17	27	14	12	16	6
Population Year 2033	13542	11417	24831	18754	5380	19032	11986	15438	7931	11355	9365	14542	5711	14470	10056	9534	8872	6030
Density [capita/ha]	56.5	208.3	532.8	285.4	77.1	255.1	894.5	908.1	511.7	737.3	787.0	826.2	337.9	539.9	739.4	801.2	558.0	942.2
2033 Household	3314	2609	5998	4218	1200	4052	2506	3790	1691	2681	2007	3716	1385	3381	2614	2484	2149	1478
2033 Connected Household	3247	2556	5878	4133	1176	3971	2456	3714	1657	2627	1967	3642	1357	3314	2562	2434	2106	1449
2033 Connected Household [%]	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%

Ward No. YEAR 2033	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2033 Inhabitants/Household	4	4	4	4	4	5	5	4	5	4	5	4	4	4	4	4	4	4
Inhabitants supplied	13271	11188	24334	18379	5273	18651	11746	15129	7773	11128	9178	14251	5597	14181	9855	9343	8695	5910
Inhabitants supplied [%]	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
Inhabitants Fully Plumbed (FP)	13000	10960	23837	18003	5165	18270	11507	14821	7614	10900	8991	13960	5483	13891	9654	9152	8517	5789
Inhabitants Fully Plumbed [%]	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%
Inhabitants Public Stand Post	271	228	497	375	108	381	240	309	159	227	187	291	114	289	201	191	177	121
Inhabitants PSP [%]	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Sp. Demand FP [lpcd]	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
Sp. Demand PSP [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Domestic Demand FP [l/d]	1755017	1479618	3218038	2430469	697301	2466508	1553384	2000772	1027891	1471561	1213738	1884616	740167	1875305	1303260	1235582	1149820	781526
Domestic Demand PSP[l/d]	13542	11417	24831	18754	5380	19032	11986	15438	7931	11355	9365	14542	5711	14470	10056	9534	8872	6030
Domestic Demand [l/d]	1768559	1491035	3242869	2449223	702681	2485540	1565370	2016210	1035822	1482916	1223104	1899157	745878	1889775	1313316	1245115	1158692	787557
Floating Pop. + Service Staff							6000									6000		
Sp. Demand Floating Pop. [lpcd]	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Demand Floating Pop. [l/d]							420000									420000		
Hospital Served Capita												80						160
Sp. Demand Hospital [lpcd]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Demand Hospitals [l/d]												27,951						55,902
2048 Pupils +Teachers	586	878	1098	1830		732	659	293	732		732			732		586	586	732
Sp. Demand School [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Demand Schools [l/d]	29282	43923	54904	91506		36603	32942	14641	36603		36603			36603		29282	29282	36603
Industrial Demand [l/]																		
Livestock Big	1897	1684	567	793	1045	244	49	509	413	1326	1465	91	1119	39	280	220	369	105
Livestock Small	152	141	208	241	545	400	166	290	241	361	334	25	123	51	52	182	114	56
Sp. Demand Livestock Big [l/c/d]	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Sp. Demand Livestock Small [l/c/d]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Demand Livestock Big [l/d]	75880	67360	22680	31720	41800	9760	1960	20360	16520	53040	58600	3640	44760	1560	11200	8800	14760	4200
Demand Livestock Small [l/d]	608	564	832	964	2180	1600	664	1160	964	1444	1336	100	492	204	208	728	456	224
Demand Livestock[l/d]	76488	67924	23512	32684	43980	11360	2624	21520	17484	54484	59936	3740	45252	1764	11408	9528	15216	4424
Fully Plumbed +PSP	3192	2513	5778	4063	1156	3903	2414	3651	1629	2582	1934	3580	1334	3257	2518	2393	2071	1424
Floating p. # Connection							6									6		
Hospitals # Connection												1						1
Schools # Connection	4	6	15	25		10	9	2	5		5			10		4	4	5
Industries # Connection																		
2033 Connection #	3,196	2,519	5,793	4,088	1,156	3,913	2,429	3,653	1,634	2,582	1,939	3,581	1,334	3,267	2,518	2,403	2,075	1,430
Sp. Water loss value [l/conn/d]	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170
Water Loss demand [l/d]	543330	428228	984857	694992	196565	665245	412906	620965	277728	438982	329573	608697	226770	555448	428130	408462	352666	243106

Ward No. YEAR 2033	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Water Loss demand [MLD]	0.54	0.43	0.98	0.69	0.20	0.67	0.41	0.62	0.28	0.44	0.33	0.61	0.23	0.56	0.43	0.41	0.35	0.24
Water Loss - as [%] of demand	22%	21%	23%	21%	21%	21%	17%	23%	20%	22%	20%	24%	22%	22%	24%	19%	23%	22%
Total Demand [l/d]	2417659	2031110	4306142	3268405	943227	3198747	2433842	2673336	1367637	1976382	1649215	2539545	1017900	2483590	1752855	2112388	1555855	1127591
Total Demand [MLD]	**2.418**	**2.031**	**4.306**	**3.268**	**0.943**	**3.199**	**2.434**	**2.673**	**1.368**	**1.976**	**1.649**	**2.540**	**1.018**	**2.484**	**1.753**	**2.112**	**1.556**	**1.128**
Served Demand/Capita [l/c/d]	182	182	177	178	179	172	207	177	176	178	180	178	182	175	178	226	179	191
Total Demand [l/s]	**27.98**	**23.51**	**49.84**	**37.83**	**10.92**	**37.02**	**28.17**	**30.94**	**15.83**	**22.87**	**19.09**	**29.39**	**11.78**	**28.75**	**20.29**	**24.45**	**18.01**	**13.05**

Ward No. YEAR 2033	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Area Year 2033	13	13	5	20	37	30	51	40	50	61	900	224	76	113	25	38	14	56
Population Year 2033	7100	6322	3730	12253	9929	9168	14293	9675	22082	15365	18005	23027	12163	8981	7177	15010	6894	17381
Density [capita/ha]	559.0	490.1	746.0	625.1	267.6	308.7	279.2	244.3	439.9	250.6	20.0	102.8	160.9	79.4	285.9	396.0	503.2	309.8
2033 Household	1585	1487	702	2494	1976	1655	2888	2152	5141	3146	4771	5252	2513	2323	1597	3153	1456	3846
2033 Connected Household	1553	1457	687	2444	1936	1621	2831	2109	5038	3083	4675	5147	2462	2277	1565	3090	1427	3770
2033 Connected Household [%]	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
2033 Inhabitants/Household	4	4	5	5	5	6	5	4	4	5	4	4	5	4	4	5	5	5
Inhabitants supplied	6958	6195	3655	12008	9730	8984	14007	9481	21640	15057	17645	22567	11920	8801	7033	14710	6756	17033
Inhabitants supplied [%]	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
Inhabitants Fully Plumbed (FP)	6816	6069	3581	11763	9532	8801	13721	9288	21199	14750	17284	22106	11676	8622	6890	14410	6618	16686
Inhabitants Fully Plumbed [%]	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%
Inhabitants Public Stand Post	142	126	75	245	199	183	286	193	442	307	360	461	243	180	144	300	138	348
Inhabitants PSP [%]	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Sp. Demand FP [lpcd]	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
Sp. Demand PSP [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Domestic Demand FP [l/d]	920106	819305	483418	1587940	1286788	1188135	1852388	1253844	2861837	1991248	2333402	2984351	1576302	1163927	930133	1945311	893429	2252551
Domestic Demand PSP[l/d]	7100	6322	3730	12253	9929	9168	14293	9675	22082	15365	18005	23027	12163	8981	7177	15010	6894	17381
Domestic Demand [l/d]	927206	825626	487148	1600193	1296717	1197303	1866681	1263519	2883919	2006613	2351407	3007379	1588465	1172907	937310	1960322	900323	2269932
Floating Pop. + Service Staff															4800			8400
Sp. Demand Floating Pop. [lpcd]	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Demand Floating Pop. [l/d]															336000			588000
Hospital Served Capita					80													
Sp. Demand Hospital [lpcd]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Demand Hospitals [l/d]					27,951													
2048 Pupils +Teachers	805	439			805			732		732				512	512			
Sp. Demand School [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Demand Schools [l/d]	40263	21962			40263			36603		36603				25622	25622			
Industrial Demand [l/]								70000										
Livestock Big	138	291		150	355	591	246	39	739	206	1750	160	395	2066	369	185		369

Ward No. YEAR 2033	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Livestock Small	97	15		115		193	162	107	881	160	359	397	130	606	366	135	65	89
Sp. Demand Livestock Big [l/c/d]	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Sp. Demand Livestock Small [l/c/d]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Demand Livestock Big [l/d]	5520	11640		6000	14200	23640	9840	1560	29560	8240	70000	6400	15800	82640	14760	7400		14760
Demand Livestock Small [l/d]	388	60		460		772	648	428	3524	640	1436	1588	520	2424	1464	540	260	356
Demand Livestock[l/d]	5908	11700		6460	14200	24412	10488	1988	33084	8880	71436	7988	16320	85064	16224	7940	260	15116
Fully Plumbed +PSP	1526	1432	676	2403	1903	1594	2783	2073	4952	3031	4596	5059	2420	2238	1539	3037	1403	3705
Floating p. # Connection															4			5
Hospitals # Connection					1													
Schools # Connection	11	3			11			10		5				7	7			
Industries # Connection								1										
2033 Connection #	1,537	1,435	676	2,403	1,915	1,594	2,783	2,084	4,952	3,036	4,596	5,059	2,420	2,245	1,550	3,037	1,403	3,710
Sp. Water loss value [l/conn/d]	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170
Water Loss demand [l/d]	261369	244032	114887	408445	325601	270960	473040	354249	841904	516065	781275	860056	411482	381698	263421	516306	238473	630771
Water Loss demand [MLD]	0.26	0.24	0.11	0.41	0.33	0.27	0.47	0.35	0.84	0.52	0.78	0.86	0.41	0.38	0.26	0.52	0.24	0.63
Water Loss - as [%] of demand	21%	22%	19%	20%	19%	18%	20%	21%	22%	20%	24%	22%	20%	23%	17%	21%	21%	18%
Total Demand [l/d]	1234746	1103320	602036	2015098	1704731	1492675	2350208	1726358	3758907	2568160	3204118	3875423	2016267	1665291	1578577	2484568	1139056	3503819
Total Demand [MLD]	**1.235**	**1.103**	**0.602**	**2.015**	**1.705**	**1.493**	**2.350**	**1.726**	**3.759**	**2.568**	**3.204**	**3.875**	**2.016**	**1.665**	**1.579**	**2.485**	**1.139**	**3.504**
Served Demand/Capita [l/c/d]	177	178	165	168	175	166	168	182	174	171	182	172	169	189	224	169	169	206
Total Demand [l/s]	**14.29**	**12.77**	**6.97**	**23.32**	**19.73**	**17.28**	**27.20**	**19.98**	**43.51**	**29.72**	**37.08**	**44.85**	**23.34**	**19.27**	**18.27**	**28.76**	**13.18**	**40.55**

Ward No. YEAR 2033	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**Total**
Area Year 2033	21	13	15	23	34	30	427	241	116	613	234	200	51	54	55	93	136	4,852
Population Year 2033	5081	11632	7647	11859	9321	10222	14219	7827	17270	13808	11014	20919	26193	21534	11725	21414	16755	675,237
Density [capita/ha]	247.9	930.5	520.2	515.6	278.2	346.5	33.3	32.4	148.9	22.5	47.2	104.8	510.6	396.6	212.4	231.3	122.8	
2033 Household	1209	2421	1809	2374	2028	2245	2947	1666	4010	3021	2315	4295	4907	5016	2604	4874	3528	150,677
2033 Connected Household	1185	2373	1773	2326	1988	2200	2888	1633	3929	2960	2269	4209	4809	4916	2551	4776	3458	147,663
2033 Connected Household [%]	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
2033 Inhabitants/Household	4	5	4	5	5	5	5	5	4	5	5	5	5	4	5	4	5	4
Inhabitants supplied	4980	11399	7494	11622	9135	10017	13934	7670	16925	13532	10794	20500	25669	21103	11490	20986	16420	661,732
Inhabitants supplied [%]	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
Inhabitants Fully Plumbed (FP)	4878	11166	7341	11385	8948	9813	13650	7514	16579	13255	10574	20082	25146	20672	11256	20557	16085	648,227
Inhabitants Fully Plumbed [%]	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%
Inhabitants Public Stand Post	102	233	153	237	186	204	284	157	345	276	220	418	524	431	234	428	335	13,505
Inhabitants PSP [%]	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Sp. Demand FP [lpcd]	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
Sp. Demand PSP [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Ward No. YEAR 2033	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**Total**
Domestic Demand FP [l/d]	658523	1507467	991008	1536912	1208009	1324745	1842751	1014368	2238227	1789487	1427458	2711079	3394656	2790757	1519545	2775240	2171456	87,510,680
Domestic Demand PSP[l/d]	5081	11632	7647	11859	9321	10222	14219	7827	17270	13808	11014	20919	26193	21534	11725	21414	16755	675,237
Domestic Demand [l/d]	663604	1519099	998654	1548771	1217330	1334967	1856969	1022195	2255497	1803295	1438472	2731998	3420849	2812290	1531270	2796654	2188211	88,185,916
Floating Pop. + Service Staff	3600	3600	3600	36000	24000				24000									120,000
Sp. Demand Floating Pop. [lpcd]	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Demand Floating Pop. [l/d]	252000	252000	252000	2520000	1680000				1680000									8,400,000
Hospital Served Capita																		319
Sp. Demand Hospital [lpcd]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Demand Hospitals [l/d]																		111,804
2048 Pupils +Teachers					878	586	732			586	732	878	732	586	293	659		21,376
Sp. Demand School [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Demand Schools [l/d]					43923	29282	36603			29282	36603	43923	36603	29282	14641	32942		1,068,793
Industrial Demand [l/]										150000		750000	900000					1,870,000
Livestock Big	201	143	81	340	259	222	239	801	1385	1239	739	585	282	418	220	2255	1046	30,719
Livestock Small	41	16	13	57	58	68	203	340	353	1087	881	266	162	286	91	145	760	12,386
Sp. Demand Livestock Big [l/c/d]	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Sp. Demand Livestock Small [l/c/d]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Demand Livestock Big [l/d]	8040	5720	3240	13600	10360	8880	9560	32040	55400	49560	29560	23400	11280	16720	8800	90200	41840	1,228,760
Demand Livestock Small [l/d]	164	64	52	228	232	272	812	1360	1412	4348	3524	1064	648	1144	364	580	3040	49,544
Demand Livestock[l/d]	8204	5784	3292	13828	10592	9152	10372	33400	56812	53908	33084	24464	11928	17864	9164	90780	44880	1,278,304
Fully Plumbed +PSP	1165	2332	1743	2287	1954	2162	2839	1605	3863	2910	2230	4138	4728	4832	2508	4695	3399	145,152
Floating p. # Connection	5	4	4	15	10				10									69
Hospitals # Connection																		3
Schools # Connection					6	4	5			4	5	6	5	8	2	9		212
Industries # Connection										200		1000	1200					2,401
2033 Connection #	1,170	2,336	1,747	2,302	1,970	2,166	2,844	1,605	3,873	3,114	2,235	5,144	5,933	4,840	2,510	4,704	3,399	147,837
Sp. Water loss value [l/conn/d]	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170
Water Loss demand [l/d]	198865	397169	296998	391285	334902	368300	483525	272868	658334	529373	379985	874409	1008530	822870	426712	799648	577826	25,132,282
Water Loss demand [MLD]	0.20	0.40	0.30	0.39	0.33	0.37	0.48	0.27	0.66	0.53	0.38	0.87	1.01	0.82	0.43	0.80	0.58	25.13
Water Loss - as [%] of demand	18%	18%	19%	9%	10%	21%	20%	21%	14%	21%	20%	20%	19%	22%	22%	21%	21%	20%
Total Demand [l/d]	1122674	2174053	1550944	4473884	3286747	1741701	2387469	1328463	4650643	2565857	1888143	4424794	5377910	3682306	1981787	3720025	2810917	126,047,099
Total Demand [MLD]	**1.123**	**2.174**	**1.551**	**4.474**	**3.287**	**1.742**	**2.387**	**1.328**	**4.651**	**2.566**	**1.888**	**4.425**	**5.378**	**3.682**	**1.982**	**3.720**	**2.811**	**126.05**
Served Demand/Capita [l/c/d]	225	191	207	385	360	174	171	173	275	190	175	216	210	174	172	177	171	190
Total Demand [l/s]	**12.99**	**25.16**	**17.95**	**51.78**	**38.04**	**20.16**	**27.63**	**15.38**	**53.83**	**29.70**	**21.85**	**51.21**	**62.24**	**42.62**	**22.94**	**43.06**	**32.53**	**1,458.88**

Ward No. YEAR 2018	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Area Year 2018	240	55	47	66	70	75	13	17	16	15	12	18	17	27	14	12	16	6
Population Year 2018	10515	8755	19280	14562	4178	14594	9191	11987	6082	8707	7182	11151	4380	11096	7711	7311	6804	4624
Density [capita/ha]	43.9	159.8	413.7	221.6	59.9	195.6	685.9	705.1	392.4	565.4	603.5	633.6	259.1	414.0	567.0	614.4	427.9	722.6
2018 Household	2067	1628	3751	2674	762	2562	1589	2363	1069	1663	1268	2270	855	2102	1591	1511	1327	910
2018 Connected Household	1964	1547	3564	2540	724	2434	1510	2244	1015	1580	1204	2156	812	1997	1512	1435	1260	865
2018 Connected Household [%]	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
2018 Inhabitants/Household	5	5	5	5	5	6	6	5	6	5	6	5	5	5	5	5	5	5
Inhabitants supplied	9989	8317	18316	13833	3969	13865	8732	11388	5778	8272	6823	10594	4161	10541	7326	6945	6463	4393
Inhabitants supplied [%]	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
Inhabitants Fully Plumbed (FP)	9148	7617	16774	12669	3635	12697	7997	10429	5291	7575	6248	9702	3810	9654	6709	6361	5919	4023
Inhabitants Fully Plumbed [%]	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
Inhabitants Public Stand Post	841	700	1542	1165	334	1168	735	959	487	697	575	892	350	888	617	585	544	370
Inhabitants PSP [%]	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Sp. Demand FP [lpcd]	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
Sp. Demand PSP [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Domestic Demand FP [l/d]	1234953	1028273	2264437	1710249	490670	1714120	1079537	1407884	714341	1022674	843497	1309729	514385	1303259	905711	858678	799077	543128
Domestic Demand PSP[l/d]	42059	35020	77120	58246	16711	58378	36766	47948	24328	34829	28727	44606	17518	44385	30846	29244	27214	18497
Domestic Demand [l/d]	1277012	1063293	2341558	1768495	507381	1772498	1116303	1455832	738669	1057503	872224	1354335	531904	1347644	936557	887922	826291	561626
Floating Pop. + Service Staff							6000									6000		
Sp. Demand Floating Pop. [lpcd]	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Demand Floating Pop. [l/d]							420000									420000		
Hospital Served Capita												66						132
Sp. Demand Hospital [lpcd]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Demand Hospitals [l/d]												23,100						46,200
2048 Pupils +Teachers	484	726	908	1513		605	545	242	605		605			605		484	484	605
Sp. Demand School [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Demand Schools [l/d]	24200	36300	45375	75625		30250	27225	12100	30250		30250			30250		24200	24200	30250
Industrial Demand [l/]																		
Livestock Big	1897	1684	567	793	1045	244	49	509	413	1326	1465	91	1119	39	280	220	369	105
Livestock Small	152	141	208	241	545	400	166	290	241	361	334	25	123	51	52	182	114	56
Sp. Demand Livestock Big [l/c/d]	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Sp. Demand Livestock Small [l/c/d]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Demand Livestock Big [l/d]	75880	67360	22680	31720	41800	9760	1960	20360	16520	53040	58600	3640	44760	1560	11200	8800	14760	4200
Demand Livestock Small [l/d]	608	564	832	964	2180	1600	664	1160	964	1444	1336	100	492	204	208	728	456	224
Demand Livestock[l/d]	76488	67924	23512	32684	43980	11360	2624	21520	17484	54484	59936	3740	45252	1764	11408	9528	15216	4424
Fully Plumbed +PSP	1826	1438	3314	2362	673	2263	1404	2087	944	1469	1120	2005	755	1857	1405	1335	1172	804
Floating p. # Connection							6									6		

Ward No. YEAR 2018	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Hospitals # Connection												1						1
Schools # Connection	4	6	15	25		10	9	2	5		5			10		4	4	5
Industries # Connection																		
2018 Connection #	1,830	1,444	3,329	2,387	673	2,273	1,419	2,089	949	1,469	1,125	2,006	755	1,867	1,405	1,345	1,176	810
Sp. Water loss value [l/conn/d]	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Water Loss demand [l/d]	274486	216659	499287	358011	100963	340928	212829	313344	142352	220345	168706	300865	113241	279991	210822	201712	176398	121530
Water Loss demand [MLD]	0.27	0.22	0.50	0.36	0.10	0.34	0.21	0.31	0.14	0.22	0.17	0.30	0.11	0.28	0.21	0.20	0.18	0.12
Water Loss - as [%] of demand	17%	16%	17%	16%	15%	16%	12%	17%	15%	17%	15%	18%	16%	17%	18%	13%	17%	16%
Total Demand [l/d]	1652186	1384175	2909732	2234815	652324	2155036	1778981	1802796	928755	1332332	1131116	1682039	690397	1659649	1158788	1543362	1042105	764029
Total Demand [MLD]	**1.652**	**1.384**	**2.910**	**2.235**	**0.652**	**2.155**	**1.779**	**1.803**	**0.929**	**1.332**	**1.131**	**1.682**	**0.690**	**1.660**	**1.159**	**1.543**	**1.042**	**0.764**
Served Demand/Capita [l/c/d]	165	166	159	162	164	155	204	158	161	161	166	159	166	157	158	222	161	174
Total Demand [l/s]	**19.12**	**16.02**	**33.68**	**25.87**	**7.55**	**24.94**	**20.59**	**20.87**	**10.75**	**15.42**	**13.09**	**19.47**	**7.99**	**19.21**	**13.41**	**17.86**	**12.06**	**8.84**

Ward No. YEAR 2018	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Area Year 2018	13	13	5	20	37	30	51	40	50	61	900	224	76	113	25	38	14	56
Population Year 2018	5444	4848	2860	9396	7614	7030	10961	7419	16934	11930	13357	17880	9327	7645	5504	11511	5286	13328
Density [capita/ha]	428.7	375.8	572.1	479.4	205.2	236.7	214.1	187.4	337.3	194.6	14.8	79.9	123.4	67.6	219.3	303.7	385.9	237.6
2018 Household	993	923	453	1589	1264	1075	1843	1350	3198	2028	2798	3320	1597	1571	1002	1998	922	2415
2018 Connected Household	944	877	430	1510	1200	1021	1751	1282	3038	1926	2658	3154	1517	1493	952	1898	876	2294
2018 Connected Household [%]	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
2018 Inhabitants/Household	5	5	6	6	6	7	6	5	5	6	5	5	6	5	5	6	6	6
Inhabitants supplied	5172	4605	2717	8926	7233	6679	10413	7048	16087	11334	12689	16986	8861	7263	5228	10935	5022	12662
Inhabitants supplied [%]	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
Inhabitants Fully Plumbed (FP)	4737	4218	2489	8174	6624	6116	9536	6455	14732	10379	11621	15556	8115	6651	4788	10014	4599	11596
Inhabitants Fully Plumbed [%]	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
Inhabitants Public Stand Post	436	388	229	752	609	562	877	594	1355	954	1069	1430	746	612	440	921	423	1066
Inhabitants PSP [%]	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Sp. Demand FP [lpcd]	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
Sp. Demand PSP [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Domestic Demand FP [l/d]	639435	569382	335956	1103552	894264	825704	1287332	871369	1988857	1401182	1568806	2099999	1095464	897906	646403	1351910	620896	1565429
Domestic Demand PSP[l/d]	21777	19391	11442	37584	30456	28121	43843	29676	67735	47720	53429	71520	37308	30580	22015	46042	21146	53314
Domestic Demand [l/d]	661213	588774	347397	1141136	924720	853825	1331175	901045	2056592	1448902	1622235	2171519	1132772	928486	668418	1397952	642042	1618742
Floating Pop. + Service Staff															4800			8400
Sp. Demand Floating Pop. [lpcd]	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Demand Floating Pop. [l/d]															336000			588000
Hospital Served Capita					66													
Sp. Demand Hospital [lpcd]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350

Ward No. YEAR 2018	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Demand Hospitals [l/d]					23,100													
2048 Pupils +Teachers	666	363			666			605		605				424	424			
Sp. Demand School [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Demand Schools [l/d]	33275	18150			33275			30250		30250				21175	21175			
Industrial Demand [l/]								70000										
Livestock Big	138	291		150	355	591	246	39	739	206	1750	160	395	2066	369	185		369
Livestock Small	97	15		115		193	162	107	881	160	359	397	130	606	366	135	65	89
Sp. Demand Livestock Big [l/c/d]	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Sp. Demand Livestock Small [l/c/d]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Demand Livestock Big [l/d]	5520	11640		6000	14200	23640	9840	1560	29560	8240	70000	6400	15800	82640	14760	7400		14760
Demand Livestock Small [l/d]	388	60		460		772	648	428	3524	640	1436	1588	520	2424	1464	540	260	356
Demand Livestock[l/d]	5908	11700		6460	14200	24412	10488	1988	33084	8880	71436	7988	16320	85064	16224	7940	260	15116
Fully Plumbed +PSP	878	815	400	1404	1116	949	1628	1192	2825	1791	2471	2933	1411	1388	885	1765	814	2133
Floating p. # Connection															4			5
Hospitals # Connection					1													
Schools # Connection	11	3			11			10		5				7	7			
Industries # Connection								1										
2018 Connection #	889	818	400	1,404	1,128	949	1,628	1,203	2,825	1,796	2,471	2,933	1,411	1,395	896	1,765	814	2,138
Sp. Water loss value [l/conn/d]	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Water Loss demand [l/d]	133276	122769	59997	210557	169233	142413	244153	180503	423710	269408	370720	439964	211590	209252	134389	264734	122155	320760
Water Loss demand [MLD]	0.13	0.12	0.06	0.21	0.17	0.14	0.24	0.18	0.42	0.27	0.37	0.44	0.21	0.21	0.13	0.26	0.12	0.32
Water Loss - as [%] of demand	16%	17%	15%	16%	15%	14%	15%	15%	17%	15%	18%	17%	16%	17%	11%	16%	16%	13%
Total Demand [l/d]	833672	741393	407394	1358152	1164528	1020650	1585815	1183786	2513385	1757440	2064391	2619471	1360682	1243977	1176206	1670626	764457	2542618
Total Demand [MLD]	**0.834**	**0.741**	**0.407**	**1.358**	**1.165**	**1.021**	**1.586**	**1.184**	**2.513**	**1.757**	**2.064**	**2.619**	**1.361**	**1.244**	**1.176**	**1.671**	**0.764**	**2.543**
Served Demand/Capita [l/c/d]	161	161	150	152	161	153	152	168	156	155	163	154	154	171	225	153	152	201
Total Demand [l/s]	**9.65**	**8.58**	**4.72**	**15.72**	**13.48**	**11.81**	**18.35**	**13.70**	**29.09**	**20.34**	**23.89**	**30.32**	**15.75**	**14.40**	**13.61**	**19.34**	**8.85**	**29.43**

Ward No. YEAR 2018	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**Total**
Area Year 2018	21	13	15	23	34	30	427	241	116	613	234	200	51	54	55	93	136	4,852
Population Year 2018	3897	11202	5864	9094	7148	7839	11553	6145	13244	10798	9408	16243	20338	16513	8991	16627	13010	524,297
Density [capita/ha]	190.1	896.2	398.9	395.4	213.4	265.7	27.1	25.5	114.2	17.6	40.3	81.4	396.5	304.1	162.9	179.6	95.4	
2018 Household	749	1930	1122	1517	1277	1411	1984	1078	2495	1938	1634	2767	3209	3120	1634	3083	2263	95,511
2018 Connected Household	712	1833	1066	1441	1214	1341	1884	1025	2371	1841	1552	2629	3049	2964	1552	2928	2150	90,735
2018 Connected Household [%]	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
2018 Inhabitants/Household	5	6	5	6	6	6	6	6	5	6	6	6	6	5	6	5	6	5
Inhabitants supplied	3702	10642	5571	8639	6790	7447	10975	5837	12582	10258	8938	15431	19321	15687	8542	15796	12359	498,083
Inhabitants supplied [%]	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%

Ward No. YEAR 2018	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	Total
Inhabitants Fully Plumbed (FP)	3390	9746	5102	7912	6219	6820	10051	5346	11522	9394	8185	14131	17694	14366	7822	14466	11318	456,139
Inhabitants Fully Plumbed [%]	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
Inhabitants Public Stand Post	312	896	469	728	572	627	924	492	1059	864	753	1299	1627	1321	719	1330	1041	41,944
Inhabitants PSP [%]	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Sp. Demand FP [lpcd]	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
Sp. Demand PSP [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Domestic Demand FP [l/d]	457646	1315702	688709	1068090	839516	920643	1356869	721682	1555474	1268235	1104979	1907705	2388718	1939459	1056020	1952854	1527989	61,578,738
Domestic Demand PSP[l/d]	15586	44809	23455	36376	28591	31354	46211	24578	52975	43192	37632	64971	81353	66052	35965	66508	52039	2,097,190
Domestic Demand [l/d]	473232	1360510	712164	1104466	868107	951997	1403080	746261	1608449	1311427	1142611	1972676	2470071	2005511	1091985	2019362	1580028	63,675,928
Floating Pop. + Service Staff	3600	3600	3600	36000	24000				24000									120,000
Sp. Demand Floating Pop. [lpcd]	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Demand Floating Pop. [l/d]	252000	252000	252000	2520000	1680000				1680000									8,400,000
Hospital Served Capita																		264
Sp. Demand Hospital [lpcd]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Demand Hospitals [l/d]																		92,400
2048 Pupils +Teachers					726	484	605			484	605	726	605	484	242	545		17,666
Sp. Demand School [lpcd]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Demand Schools [l/d]					36300	24200	30250			24200	30250	36300	30250	24200	12100	27225		883,300
Industrial Demand [l/]										150000		750000	900000					1,870,000
Livestock Big	201	143	81	340	259	222	239	801	1385	1239	739	585	282	418	220	2255	1046	30,719
Livestock Small	41	16	13	57	58	68	203	340	353	1087	881	266	162	286	91	145	760	12,386
Sp. Demand Livestock Big [l/c/d]	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Sp. Demand Livestock Small [l/c/d]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Demand Livestock Big [l/d]	8040	5720	3240	13600	10360	8880	9560	32040	55400	49560	29560	23400	11280	16720	8800	90200	41840	1,228,760
Demand Livestock Small [l/d]	164	64	52	228	232	272	812	1360	1412	4348	3524	1064	648	1144	364	580	3040	49,544
Demand Livestock[l/d]	8204	5784	3292	13828	10592	9152	10372	33400	56812	53908	33084	24464	11928	17864	9164	90780	44880	1,278,304
Fully Plumbed +PSP	662	1705	991	1340	1128	1247	1752	953	2204	1712	1443	2444	2835	2756	1443	2723	1999	84,368
Floating p. # Connection	5	4	4	15	10				10									69
Hospitals # Connection																		3
Schools # Connection					6	4	5			4	5	6	5	8	2	9		212
Industries # Connection										200		1000	1200					2,401
2018 Connection #	667	1,709	995	1,355	1,144	1,251	1,757	953	2,214	1,916	1,448	3,450	4,040	2,764	1,445	2,732	1,999	87,053
Sp. Water loss value [l/conn/d]	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Water Loss demand [l/d]	99991	256320	149269	203212	171665	187617	263570	142899	332140	287419	217258	517510	605970	414597	216771	409788	299857	13,057,904
Water Loss demand [MLD]	0.10	0.26	0.15	0.20	0.17	0.19	0.26	0.14	0.33	0.29	0.22	0.52	0.61	0.41	0.22	0.41	0.30	13.06
Water Loss - as [%] of demand	12%	14%	13%	5%	6%	16%	15%	15%	9%	16%	15%	16%	15%	17%	16%	16%	16%	15%
Total Demand [l/d]	833427	1874615	1116726	3841506	2766664	1172966	1707272	922559	3677401	1826954	1423203	3300950	4018219	2462172	1330021	2547156	1924764	89,257,836

Ward No. YEAR 2018	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	Total
Total Demand [MLD]	**0.833**	**1.875**	**1.117**	**3.842**	**2.767**	**1.173**	**1.707**	**0.923**	**3.677**	**1.827**	**1.423**	**3.301**	**4.018**	**2.462**	**1.330**	**2.547**	**1.925**	**89.26**
Served Demand/Capita [l/c/d]	225	176	200	445	407	158	156	158	292	178	159	214	208	157	156	161	156	179
Total Demand [l/s]	**9.65**	**21.70**	**12.93**	**44.46**	**32.02**	**13.58**	**19.76**	**10.68**	**42.56**	**21.15**	**16.47**	**38.21**	**46.51**	**28.50**	**15.39**	**29.48**	**22.28**	**1,033.08**

15.3. PUMP SET CAPACITIES

The capacity of proposed pumping sets & head has been arrived at based on actual physical measurement of tube well discharge & also capacity of aquifer tapped all around. The pumping set installed at the existing tube well locations is proposed to be replaced and delivery pipe and flow meters to be provided as per Table 28 below:

Table 28: Proposed pumping sets at existing tube wells

ID	Name of Tube Well	Q (m^3/h)	Head (m)	HP	Delivery Pipe Size (mm)	Flow Meter Size (mm)
1	Dandibagh No. 1	220	85	105	200	200
2	Dandibagh No. 2	220	85	105	200	200
3	Dandibagh No. 3	220	85	105	200	200
4	Dandibagh No. 4	220	85	105	200	200
5	Dandibagh No. 5	220	85	105	200	200
6	Panchayati Akhara No. 1	100	65	40	150	150
7	Panchayati Akhara No. 2	100	65	40	150	150
8	Azad Park	55	49	25	100	100
9	Dhobighat	40	69	20	100	100
10	Central School	75	70	35	125	125
11	Nigam Store	20	71	10	80	80
12	Gurudwara	55	71	25	100	100
14	New Godown	55	71	25	100	100
15	Kharkhura	40	53	15	100	100
16	Delha	40	53	15	100	100
17	Panchayati Akhara No. 3	100	65	40	150	150
18	Janata Colony 1	40	71	20	100	100
19	Janata Colony 2	20	71	10	80	80
20	Pilgrim Hospital	20	49	7.5	80	80
21	Vishnupad	130	95	70	150	150
22	Bypass	75	95	45	125	125
23	Bairagi Powerganj	55	71	25	100	100
24	Bageshwari Paschim	20	69	10	80	80
25	Pitamaheshwar	75	71	35	125	125
26	Kauvasthan	20	49	7.5	80	80
27	Hata Godown	55	71	25	100	100
28	Manpur	100	69	40	150	150
29	Manpur - Buniyadiganj	75	43	20	125	125
30	Khadi Gramodyog Lakhibagh	55	47	15	100	100

15.4. RISING MAIN PIPE LINES

The rising mains to ground level / overhead service reservoirs located at various places of the Gaya town have been designed based on proposed pumping rate from the TW and most techno-economical system over a period of 30 years has been proposed. The details of the rising mains and their connection details are presented in Table 29 and Table 30

Table 29: Details of rising mains pipe line sizes

ID.	Reservoir Location	Diameter	DMAs connected	TW
		mm		Connected
1	Joda Maszid	450	2, 3	32
2	Patan Poli (Phase-II)			
3	Budva Mahadev		1	Package-2
4	Mastalipur	350	4, 5	28, 33
5	Busunda Mela	200	6, 7	34,30
6 &7	Ramshila Hill GLSR	400	8, 9	6, 7, 9, 17, 24,31
8	Murli Hills GLSR	350	10	10, 11, 12, 14, 18, 19, 23, 25, 27
9	Ajad Park	200	Ward 15, DMA 13	8, 20, 26
10c	Brahmayoni Hills GLSR		11, 12, 13, 14, 17,	1, 2, 3, 4, 5, 22
10d	Brahmayoni Hills GLSR		21, 22, 23, 24, 25, 26, 27	
10a	Brahmayoni Hills GLSR	600		
10b	Brahmayoni Hills GLSR			
11	Brahmayoni Hills GLSR	450		
12	Brahmayoni Hills GLSR	350		
13a+13b	Shringh Sthan	450	15, 16, 18, 19, 20	35, 36, 37, 38, 39
14	Kharkura Raja koti	150	29	15, 16
16	Behind Delha PS		28, 30	Package-2

Table 30: Sample of a design for economic size of rising main

Discharge at Ultimate Stage 2048	**lps**	**lpm**	**m^3/hr**	**m^3/s**					
	47.22	**2833**	**170.0**	**0.05**					
Physical Data									
Length of rising main (m)	1000								
Maximum velocity (m/sec)	3								
Minimum velocity (m/sec)	0.6								
Relative density of water to be pumped	1								
Overall efficiency of pumping plant	72%								
Cost of electrical energy per unit (Rs.)	6								
Pump Equipment cost per KW (Rs.)	40000.00								
Type of pipe to be used	DI K9								
Manning constant 'C'	100								
Velocity Head (m) / Terminal Head	2.00								
Frictional loss in PH (m)	2.00								
Interest rate of Loan (%)	10								
Life cycle period of project (yrs)	15								
Capital recovery factor	0.13147								
RL of minimum water level (m)									
RL of discharge point(m)									

Total static head (m)	**60.17**								
Cost of electrical energy consumed per meter head									
Total days per year for pumping	365								
Hours of flow	24								
Discharge to be pumped (Lps)	47.22								
Quantity of water pumped (Kg/sec)	47.22								
Electical energy input (KW/m)	0.643								
No. Of units cosumed per year (KWH/m)	5633								
Cost of electrical energy per year per meter head (Rs.)	33796.30								
Calculation for economic size of DI, K9 rising main									
Rate	908	1084	1316	1804	2503	3029	3793	4414	5245
Dia meter of pipe	100	125	150	200	250	300	350	400	450
Per meter cost of pipeline including taxes, laying etc.	1271.2	1517.6	1842.4	2525.6	3504.2	4240.6	5310.2	6179.6	7343
Cost of pipe line for total length (Rs. In Lacs)	12.712	15.176	18.424	25.256	35.042	42.406	53.102	61.796	73.43
Cost of Pump including 25% Stand by (Rs. In Lacs)	80.6	42.5	29.8	22.3	20.5	19.8	19.6	19.5	19.4
Capital cost (Line & Pump) (Rs. In Lacs)	93.3	57.6	48.2	47.6	55.5	62.3	72.7	81.3	92.9
Total annual capitalized (Rs. In Lacs)	12.273	7.578	6.335	6.253	7.297	8.185	9.558	10.687	12.21
Total frictional losses including 10% extra for bends etc.	190.651	71.902	32.413	9.220	3.477	1.568	0.799	0.446	0.267
Total Head including static head at Discharge 2047	250.816	132.067	92.578	69.385	63.642	61.733	60.964	60.611	60.43
Annual energy consumption (Rs. In Lacs) at Discharge 2047	84.77	44.63	31.29	23.45	21.51	20.86	20.60	20.48	20.42

Total annualised cost (Rs. In Lacs)	**97.04**	**52.21**	**37.62**	**29.70**	**28.81**	**29.05**	**30.16**	**31.17**	**32.63**
Velocity (m/sec)	6.010	3.846	2.671	1.503	0.962	0.668	0.491	0.376	0.297
Considering the velocity criteria and the capitalized cost, the economic diameter as					250				
Discharge in m^3/sec	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Diameter in m	0.10	0.13	0.15	0.20	0.25	0.30	0.35	0.40	0.45
Length of line in m	1000	1000	1000	1000	1000	1000	1000	1000.	1000.
$h=[10.674 \times Q^{1.852} \times L]/[C^{1.852} \times D^{4.87}]$	173.32	65.37	29.47	8.38	3.16	1.43	0.73	0.41	0.24
h – frictional head loss m, L – length in m, D – Internal dia in m, Q – Discharge in m3/sec, C – Pipe roughness coefficient									
Recommended size of rising main	**250**	**mm**							

15.4.1. PUMP HEAD CALCULATIONS

Table 31: Design of Rising Main Pipe lines from Tube Wells to Service Reservoirs

TW ID	Description	Flow	Pumping level in TW	m³/h	MLD	m³/s	Length of Rising main (m)	Size of Rising main (m)	Velocity in RM in m/sec	Diff of RL of Bottom of Tank and GL near TW	Water column in reservoir (m)	Total Static Lift	Pumping to Reservoir	Friction loss from junction to junction	Total Frictional losses m	Vel Head + Pump House losses	Total Head in m
1	Dandibagh TW 1	220	12.5	220	5.28	0.0611	300	0.3	0.86	57.57	6	76.07	Brahmyoni	1.36	4.95	4	85.02
4	Dandibagh TW 4	220	12.5	220	5.28	0.0611	200	0.25	1.24	57.57	6	76.07	Brahmyoni	2.21	5.80	4	85.87
5	Dandibagh TW 5	220	12.5	220	5.28	0.0611	300	0.25	1.24	57.57	6	76.07	Brahmyoni	3.32	6.90	4	86.97
	Combined Discharge 1,4 &5					0.1833	3000	0.6	0.65					3.59			
2	Dandibagh TW 2	220	12.5	220	5.28	0.0611	50	0.2	1.94	57.57	6	76.07	Brahmyoni	1.64	8.08	4	88.15
		220	12.5	220	5.28	0.0611	3000	0.35	0.63			12.5		6.44			
3	Dandibagh TW 3	220	12.5	220	5.28	0.0611	100	0.25	1.24	57.57	6	76.07	Brahmyoni	1.11	2.24	4	82.31
		220	12.5	220	5.28	0.0611	3000	0.5	0.31					1.13			
21	Visnupad	129.06	12.5	130	3.12	0.0361	50	0.25	0.74	59.57	6	78.07	(Baba Dayalu Nath Mandir)	0.21	10.56	4	92.63
22	Bypass	79.78	12.5	75	1.8	0.0208	50	0.2	0.66	59.57	6	78.07	(Baba Dayalu Nath Mandir)	0.22	10.58	4	92.65
	Combined Discharge of 1&2			205	4.92	0.0569	5500	0.35	0.59					10.36			
6	Panchayati Akhara No. 1	104.13	12.5	100	2.4	0.0278	50	0.20	0.88	33.2	6	51.7	Ramshila	0.38	8.79	4	64.49
7	Panchayati Akhara No. 2	94.376	12.5	100	2.4	0.0278	50	0.20	0.88	33.2	6	51.7	Ramshila	0.38	8.79	4	64.49
17	Panchayati Akhara No. 3	94.376	12.5	100	2.4	0.0278	50	0.20	0.88	33.20	6	51.7	Ramshila	0.38	8.79	4	64.49
	Combined Discharge of 1,2,3			300	7.2	0.0833	1500	0.35	0.87					5.73			
9	Dhobighat	36.82	15.5	40	0.96	0.0111	50	0.15	0.63	33.2	6	54.7	Ramshila	0.28	2.96	4	61.66
24	Bageshwari Pachim	18.84	18	20	0.48	0.0056	1000	0.125	0.45	33.2	6	56.7	Ramshila	3.76	6.44	4	67.14
	Combined Discharge of 5 nos.			360	8.64	0.1000	500	0.35	1.04					2.68			
28	Manpur	92.57	34	100	2.4	0.0278	2500	0.25	0.57	20	5	58.5	(Gauri Kanya)	6.39	6.39	4	68.89
30	Khadigramodyog Lakhibagh	53.37	16	55	1.32	0.0153	30	0.15	0.86	20	5	40.5	(Gauri Kanya)	0.30	5.49	4	49.99
	Combined Discharge of 2 nos.			155	3.72	0.0431	900	0.25	0.88					5.19			
34	Kirl 3, Near Bridge	75.00	34	75	1.8	0.0208	1200	0.2	0.66	20	5	58.5	(Muffassil Thana)	5.33	5.33	4	67.83
33	Kirl 2, Maffassil Thana	170.00	13	170	4.08	0.0472	100	0.25	0.96	20	5	37.5	(Muffassil Thana)	0.68	0.68	4	42.18
29	Manpur – Buniydiganj	64.61	12.5	75	1.8	0.021	1500	0.2	0.66	20	5	37.5	(Urdu Mohd. Tola	6.66	6.66	4	48.16
												0					
32	Kirl 1, Joda Masjid	150	12.5	150	3.6	0.042	150	0.25	0.85	20	5	37.5	(Joda Masjid)	0.81	0.81	4	42.31

T W ID	Description	Flow	Pumping level in TW	m³/h	MLD	m³/s	Length of Rising main (m)	Size of Rising main (m)	Velocity in RM in m/sec	Diff of RL of Bottom of Tank and GL near TW	Water column in reservoir (m)	Total Static Lift	Pumping to Reservoir	Friction loss from junction to junction	Total Frictional losses m	Vel Head + Pump House losses	Total Head in m
18	Janata Colony 1	38.60	15.5	40	0.96	0.0111	50	0.15	0.63	35.67	6	57.165	Murli Hill	0.28	3.21	4	64.38
19	Janata Colony 2	17.686	15.5	20	0.48	0.0056	50	0.125	0.45	35.67	6	57.165	Murli Hill	0.19	3.12	4	64.29
	Combined Discharge of 1&2			60	1.44	0.0167	1000	0.2	0.53					2.93			
10	Central School	79.06	18.5	75	1.8	0.0208	500	0.2	0.66	35.67	6	60.165	Murli Hill	2.22	6.38	4	70.55
14	New Godown	50.41	18.5	55	1.32	0.0153	50	0.2	0.49	35.67	6	60.165	Murli Hill	0.12	4.29	4	68.45
	Combined Discharge of 1&2			130	3.12	0.0361	1000	0.25	0.74					4.16			
12	Gurudwara	55.65	15.5	55	1.32	0.0153	50	0.2	0.49	35.67	6	57.165	Murli Hill	0.12	3.05	4	64.22
11	Nigam Store	23.18	15.5	20	0.48	0.0056	50	0.125	0.45	35.67	6	57.165	Murli Hill	0.19	3.12	4	64.28
23	Bairagi Powerganj	60	18.5	55	1.32	0.0153	1000	0.2	0.49	35.67	6	60.165	Murli Hill	2.50	5.42	4	69.59
25	Pitamaheshwar	64.54	15.5	75	1.8	0.021	50	0.25	0.42	35.67	6	57.165	Murli Hill	0.07	3.00	4	64.17
27	Hata Godown	52.46	15.5	55	1.32	0.0153	50	0.2	0.49	35.67	6	57.165	Murli Hill	0.12	3.05	4	64.22
	Combined Discharge of 5			260	6.24	0.0722	1000	0.35	0.75					2.93			
26	Kauvasthan	16.54	12.50	20	0.48	0.0056	900	0.125	0.45	20	5	37.5	Azad Park	3.39	3.85	4	45.35
8	Azad Park	52.34	15.50	55	1.32	0.0153	50	0.2	0.49	20	5	40.5	Azad Park	0.12	0.59	4	45.09
20	Pilgrim Hospital	16.90	12.50	20	0.48	0.0056	300	0.125	0.45	20	5	37.5	Azad Park	1.13	1.59	4	43.09
	Combined discharge of 3			95	2.28	0.0264	200	0.25	0.54					0.46			
15	Kharkhura	45.94	18.50	40	0.96	0.0111	50	0.15	0.63	20	5	43.5	(Khurkhura Raja Kothi)	0.28	7.79	4	55.29
16	Delha	45.40	12.50	40	0.96	0.0111	500	0.15	0.63	20	5	37.5	(Khurkhura Raja Kothi)	2.81	10.31	4	51.81

15.5. GROUND LEVEL AND OVER HEAD SERVICE RESERVOIR CAPACITIES

The capacities of the ground level and overhead service reservoirs have been calculated based on the water demand of the DMAs to be served and has been determined as 25% of daily water demand of DMAs served for the design year 2048 and are given below:

Table 32: Details of designed storage capacities

ID	Reservoir Location	Capacity (ML)	Type	DMA No.	Demand for Year-2048 (MLD)	Action
1	Near Joda Masjid	2.15	OHT	2,3	12.709	Phase-I
2	Patan Toli	1.50	OHT			Phase-II
3	Near Budvamahadev Mandir	1.71	OHT	1	2.25	Phase-I
4	Mastalipur	2.00	OHT	4,5	7.587	Phase-I
5	Busunda	2.15	OHSR	6, 7	8.592	Phase-I
6 & 7	Ramshila Hill	0.22 + 2.6	GLSR	8,9	10.248	Existing (*one additional GLSR 2.6MLto be provided)
8a &8b	Murli Hills	1.63	GLSR	10, 12	5.326	Existing
9	Ajad Park	0.45	OHT	Ward 15, DMA 13	2.324	Existing
10a	Brahmayoni Hills	1.816	GLSR	11, 13, 14,	68.763	Existing two tanks to be repaired and two new tanks of 4.64ML capacity each to be constructed
10b	Brahmayoni Hills	1.816	GLSR	17,21,22, 23,		
11	Brahmayoni Hills	3.632	GLSR			Existing
12	Brahmayoni Hills	3.632	GLSR			Existing
13a & 13b	Shring Sthan	4.54+ *3.7	GLSR	15, 16, 18, 19, 20	32.698	Existing (*Additional storage 3.7ML to be provided)
14	Kharkhura Raja Kothi	1.5	OHT	29	5.546	Phase-I
16	Behind Delha PS	2.15	OHT	28, 30	7.27	

15.6. DISTRIBUTION NETWORK DESIGN

The following design features are taken into consideration for DMA wise distribution system designs.

Design feature	Description
Design Period	30 Years
Population	5,24,297 for year 2018
	6,75,237 for year 2033
	8,48,200 for year 2048
Per capita demand	135 litres per capita per day + NRW@200l/connection/day
Peak factor	2
Pipe material	HDPE with PE80 PN6 and DI-K7
Pipe sizes	HDPE: 110 mm to 315 mm and dead-end pipes 90 mm
	DI : 350 mm & above
Head loss calculations based on	Hazen Williams Formula
'C' value used for design	140 for DI and 145 for HDPE

The distribution network design output/hydraulic statements DMA wise have been produced in **Volume II** of this DPR.

As a result of distribution network designs in each DMA the diameter wise lengths have been produced in the Table 33 below:

Table 33: DMA details with diameter wise lengths

DMA No.	Existing									Proposed												
	100	150	200	250	300	350	400	450	Sub Total	110	150	200	250	300	350	400	450	500	600	700	Sub total	Total
1	978		1447	254	121				2800	12913	3971			101							16985	19785
2	204	155	386						745	5044	2715	321	889	146	513	350					9978	10723
3	59		2741		282				3082	6182	1163	1056		337	373		340				9451	12533
4	1640	760	1937	108	92				4537	8521	420		336		5		2201				11483	16020
5										7517	1642	282	45	206	196						9888	9888
6	1532		2090		251		281	570	4724	15076	693	1150		8							16927	21651
7	1448	789	1308		74		491		4110	10245	3847	1380				467					15939	20049
8										8347.82	4352.47		883.79		617.39	581.51					14783	14783
9										5986.56	855.75	856.26	307.09	689.48		187.42		136.16			9019	9019
10										12299.18	1231.64	696.08	70.47	286.12	17.95	123.05		144.18			14869	14869
11										6794.33	1930.41	820.86	520.54	1704.76		302.27		6.03	395		12474	12474
12										6550.49	1554.99	778.37	146.43	429.27	246.28						9706	9706
13										5468.87	1313.49	634.66	285.17	130.28	305.13	390.17	169.97	2.66			8700	8700
14										6891.07	2316.12	699.78	838.83	93.96	146.45	2.46					10989	10989
15	1483	16				63		58	1620	5455	1299	335	215	306	661		1012				9283	10903
16	6398	1840	167				87		8492	10376	1492	585	738	438		3					13632	22124
17	865.71	377.42							1243	9127.51	1232.62	907.48	557.75	839.37	491.87	1093.19					14250	15493
18	555	978		35	139	279	173		2159	25106	5225	4433	2156	403							37323	39482
19	5189	5031	1312	323	287	942	632	88	13804	18222	4473	915	618	297	81		1164				25770	39574
20	3460	3593	2335	698			2655		12741	13631	1412	649	345			222	188	1074	802	1257	19580	32321
21	717.5		593.65						1311	13551.19	1931.3	109.82	1811.62	344.29	233.9						17982	19293
22										7703.52	1491.28	710.81	502.86	74.11	377.59	54.24			3145.97		14060	14060
23		255.19							255	10914.32	1736.73	327.65	941.22	50.26	24.42	5		4.99	554.02		14559	14814
24										6806.14	1628.78	1888.43	264.27	186.8	178.81	112.28	81.87	857.69		883.95	12889	12889
25	2966.34	242.07				436.45		564.15	4209	20504.36	3615.32	2223.35	1374.91		262.07						27980	32189
26	2414.62	561	1175.44	634.67				992.2	5778	4949.11	1852.27	1512.83	281.47	263.85	1090.72	2.49	199.17				10152	15930
27	844.84								845	5138.84	1233.21	3649.25	3385.84	242.49							13650	14494
28										15471	2991	829	896	473	459						21119	21119
29										7678	972	677	339	271	40	581					10558	10558
30										8532	1763	1203	170	810			20				12498	12498
Grand Total	**30755**	**14598**	**15492**	**2053**	**1246**	**1720**	**4319**	**2272**	**72455**	**301002**	**62354**	**29631**	**18919**	**9131**	**6321**	**4477**	**5376**	**2226**	**4897**	**2141**	**446475**	**518930**