Bihar Urban Infrastructure Development Corporation Ltd.

Bihar Urban Development Investment Program – BUDIP

DETAILED PROJECT REPORT

IMPROVEMENT OF THE WATER SUPPLY SYSTEM PACKAGE-1 FOR GAYA MUNICIPAL CORPORATION

For

GAYA

VOLUME I

Main Report

July 2015

Prepared by

DSC CONSULTANT

Shah Technical Consultants Pvt. Limited in association with:

IPE Global Pvt. Limited

Cogent Training Research Development Consultant Pvt. Ltd.

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AMR	Automatic Meter Reading
AWWA	American Water Works Association
bar	Pressure unit: 1 bar ~ 10 metres of water column
cm	Centimetre
BOD_5	Biochemical Oxygen Demand at 5 days
BUIDCo	Bihar Urban Infrastructure Development Corporation
BUDIP	Bihar Urban Development Investment Programme
CDP	City Development Plan
COD	Chemical Oxygen Demand
CPHEEO	Central Public Health and Environmental Engineering Organisation
d	Day
DBO	Design Build Operate
DCI	Ductile Cast Iron (material for pipelines and fittings)
DI	Ductile Iron (material for pipelines and fittings)
DIN	Deutsches Institut für Normung (German Institute for Norming)
DMA	District Metered Area
DPR	Detailed Project Report
DN	Nominal Diameter (refers to metallic pipelines)
DSC	Design and Supervision Consultant
EA	Executing Agency – UDHD
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FFA	Framework Financing Agreement dated 31 January 2012 between ADB and the Borrower with respect to the MFF
Ø or Dia.	Greek letter “phi” used by engineers to abbreviate the diameter of a pipe
FP	Fully Plumbed
GLSR	Ground Level Service Reservoir
GMC	Gaya Municipal Corporation
GoB	Government of Bihar
GoI	Government of India
GWB	Gaya Water Board
h	Hour
ha or Ha	Hectare
HH	House Hold
HDPE	High Density Poly Ethylene (material for pipelines)
HP	Horse Power; 1HP = 0.7354987 kW = 735.4987 Nm/s (Newton metre / second)
HSC	House Service Connection
ID	Identification Number
IBNET	International Benchmarking Network
IFA	International Financing Agency
IFI	International Financing Institution
ISO	International Organisation for Standardisation

Kg	Kilogramme
Kg/h	Kilogramme per hour
KPI	Key Performance Indicator
Km	Kilometre
kVA	Kilo Volt Ampere
kW	Kilowatt
kWh	Kilowatt hour
l	litre
L	Length
LEAP	Local Environmental Plan
LOS	Levels of Service
l/d or lpd	Litres per day
l/h or lph	Litres per hour
l/m or lpm	Litres per minute
lpcd or l/c/d	Litres per capita per day (referring to the consumption of water)
l/s or lps	Litres per second
m.a.s.l.	metres above (normal) sea level
m	metre
m^2	square metre
m^3	Cubic metre
m^3/d	cubic metres per day
m^3/h	cubic metres per hour
m^3/y	cubic metres per year
MDPE	Medium Density Polyethylene
MFF	Multi-tranche Financing Facility
mld or MLD	1 Mega l/d = 1,000,000 l/d = 1000 m^3/d
mm	Millimetre
NRW	Non-Revenue Water
NSLB	National Service Level Benchmark
NTPA	Technical Norms for Water Protection
NTU	Nephelometric Turbidity Unit
OD	Outer Diameter (refers to non-metallic pipelines)
OJT	On the Job Training
OHSR	Overhead Service Reservoir
OHT	Overhead Tank/Reservoir
OHASAS	Occupational Health and Safety Standard
O&M	Operation and Maintenance
PD	Project Director
PE	Poly Ethylene (material for pipelines and fittings)
PHED	Public Health Engineering Department
PI	Performance Indicator
PIU	Project Implementation Unit
PMC	Project Management Consultant
PMU	Programme Management Unit

PN	Nominal Pressure (normally followed by a number that represents bar)
PPTA	Project Preparatory Technical Assistance
PRV	Pressure-reducing Valve
PSP	Public Stand post
ppm	parts per million = milligrams per litre
PVC	Polyvinylchloride (material for pipelines and fittings)
RCC	Reinforced Cement Concrete
RF	Resettlement Framework
RP	Resettlement Plan
SAR	Subproject Appraisal Report
SCADA	Supervisory Control And Data Acquisition
SDR	Standard Dimension Ratio for HDPE pipes (outer diameter / pipe wall thickness)
SEIAA	State Environment Impact Assessment Authority
SPUR	Support Program for Urban Reforms
SS	Suspended Solids
STC	Shah Technical Consultants
STP	Sewage Treatment Plant (or WWTP)
TA	Technical Assistance
TC	Town Committee
ToR or TOR	Terms of Reference
TM	Transmission Main
TSS	Total Suspended Solids
UDHD	Urban Development and Housing Department
UfW	Unaccounted for Water replaced by NRW in common engineering terminology
ULB	Urban Local Body
VAT	Value Added Tax
WHO	World Health Organization
WTP	Water Treatment Plant
WWTP	Waste Water Treatment Plant
YT	Yard Tap

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF FIGURES

LIST OF DRAWINGS – in VOL III

S NO.	DRAWING TITLE	DRAWING NO.
1	MAP SHOWING PROJECT AREA	BUDIP-2/GA/WS/01/01
2	LAYOUT OF EXISTING WATER SUPPLY SYSTEM	BUDIP-2/GA/WS/01/02
3	MAP SHOWING WARD/DMA BOUNDARIES	BUDIP-2/GA/WS/01/03
4	MAP SHOWING PROPOSED RISING MAINS AND DISTRIBUTION MAINS	BUDIP-2/GA/WS/01/04
5	KEY PLAN OF EXISTING AND PROPOSED DISTRIBUTION SYSTEM	BUDIP-2/GA/WS/01/05
6	SLD FOR TYPICAL ELECTRICAL SYSTEM FOR TUBEWELLS	BUDIP-2/GA/WS/01/06
7	SLD OF ELECTRICAL SYSTEM AT DANDIBAGH	BUDIP-2/GA/WS/01/07
8	TYPICAL DRAWING OF PUMP HOUSE	BUDIP-2/GA/WS/01/08
9	GENERAL ARRANGEMENT OF OVER HEAD TANK AT JODA MASJID	BUDIP-2/GA/WS/01/09
10	GENERAL ARRANGEMENT OF OVER HEAD TANK AT BUDVA MAHADEV MANDIR	BUDIP-2/GA/WS/01/10
11	GENERAL ARRANGEMENT OF OVER HEAD TANK AT MASTALIPUR	BUDIP-2/GA/WS/01/11
12	GENERAL ARRANGEMENT OF OVER HEAD TANK AT BUSUNDA MELA	BUDIP-2/GA/WS/01/12
13	GENERAL ARRANGEMENT OF GROUND LEVEL SERVICE RESERVOIR ON RAMSHILA HILL	BUDIP-2/GA/WS/01/13
14	GENERAL ARRANGEMENT OF GROUND LEVEL SERVICE RESERVOIR ON BRAHMYONI HILL	BUDIP-2/GA/WS/01/14
15	GENERAL ARRANGEMENT OF OVER HEAD TANK AT KHARKURA RAJA KOTI	BUDIP-2/GA/WS/01/15
16	GENERAL ARRANGEMENT OF OVER HEAD TANK AT BEHIND DELHA POLICE STATION	BUDIP-2/GA/WS/01/16
17	TYPICAL DRAWING OF MONITORING STATION ARRANGEMENT	BUDIP-2/GA/WS/01/17
18	PLAN OF OPERATING OFFICE CUM CUSTOMER SERVICE CENTER CUM SERVICE OFFICE	BUDIP-2/GA/WS/01/18
19	TYPICAL CROSS SECTIONS OF PIPE LINE TRENCH	BUDIP-2/GA/WS/01/19
20	TYPICAL DRAWING OF AIR RELEASE VALVE CHAMBER	BUDIP-2/GA/WS/01/20

S NO.	DRAWING TITLE	DRAWING NO.
21	TYPICAL DRAWING OF SLUICE VALVE CHAMBER	BUDIP-2/GA/WS/01/21
22	TYPICAL DRAWING OF BUTTERFLY VALVE CHAMBER	BUDIP-2/GA/WS/01/22
23	TYPICAL DRAWING OF SCOUR VALVE CHAMBER	BUDIP-2/GA/WS/01/23
24	TYPICAL DRAWING OF SPECIALS FOR VALVE FITTINGS	BUDIP-2/GA/WS/01/24
25	TYPICAL DRAWING OF FIRE HYDRANTS	BUDIP-2/GA/WS/01/25
26	TYPICAL DRAWING OF HOUSE SERVICE CONNECTION	BUDIP-2/GA/WS/01/26
27	TYPICAL DRAWING OF PUBLIC STAND POST	BUDIP-2/GA/WS/01/27
28	TYPICAL DRAWING OF WATER FLOW & PRESSURE LOGGER CHAMBER	BUDIP-2/GA/WS/01/28
29	DRAWING FOR DETAILS OF THRUST BLOCK	BUDIP-2/GA/WS/01/29
30	TYPICAL DRAWING OF NATIONAL HIGH WAY CROSSING	BUDIP-2/GA/WS/01/30
31	TYPICAL DRAWING OF RAILWAY CROSSING	BUDIP-2/GA/WS/01/31
32	TYPICAL DRAWING OF NALLAH CROSSING	BUDIP-2/GA/WS/01/32

0. EXECUTIVE SUMMARY

Bihar is one of the major states in eastern India, being the third largest by population and twelfth largest by geographical area. The urban service delivery e.g. water supply, sewerage and solid waste management, etc. in the state are not adequate and are below the national and state benchmarks. The water supply lacks uniformity in improvement in terms of coverage, quantity and duration. The condition of these facilities in Gaya is not exceptional, indicating an immediate need of attention.

Due to the uncertainty related to the availability of water resources for the future and in the absence of reliable hydro-geological investigation that is now under preparation, the measures for the Improvement of The Water Supply System in Gaya had to be broken in 2 packages:

Package 1 (this Report) deals with the refurbishing of the existing water production facilities, consolidation, renovation, and extension of the pipes work, augmentation of the storage capacities, introduction of tools for monitoring the production and the consumption of water, and last but not the least, the capacity building of GMC for ensuring the sustainability of the project.

Package 2 deals with the determination of the capacity of the aquifer, design and implementation of additional water production capacities in case of need, and design and implementation of related transmission facilities of the additional water volumes to the town.

It is essential that Package 2 is finalised in the same time with the Package 1 according to the results of the hydro-geological investigation.

Additional storage capacities will be needed now at few locations. The storage capacities are normally provided for a design period of 30 years. However, in outer areas of the city it is not known at what locations they will be constructed as urban planning of that horizon is not available. Accordingly, construction of such storages has not been included in the present proposals. Such deferred reservoirs may be taken up later when urban planning of such areas is either finalised or the areas gets substantially developed.

The objective of the present DPR is to define the measures needed in Gaya for improving in a sustainable manner the water supply to the population except for additional water requirement to meet projected demand for design year 2048.

The DPR is presented in following four volumes:

Volume I:	General Report
Volume II:	Network hydraulic design
Volume III:	Drawings
Volume IV:	Confidential Cost Estimates including unit rates

0.1. EXISTING SYSTEM

The existing water supply system is not covering the entire urbanised area. DSC's investigations have shown that a large proportion of the population connected to the piped water supply system is not using it due to unreliable water quality and/or intermittent supply and prefers to use private wells.

The water sources of Gaya consist of underground water extracted by tube wells located on both sides of the River Phalgu, Manpur and Gaya main. There are 39 tube wells in the town at present of which one is meant for fire fighting, one has become defunct and 2 are standby.

The existing distribution system is not in conformity with basic engineering practices. Part of it consists of Transmission Mains raising the water to 1 Over Head Tank and 7 Ground Level Reservoirs on hills. The other part is operated by pumping the Tube Wells water directly into the distribution network. For this portion no storage capacities are available.

The total existing storage capacity is of 17747 m³.

The reservoirs constructed on Ramshila hills, Murli hills and overhead tank at Azad Park are not functional at present as these tanks are not being fed due to inadequate capacity of the pumping plants on respective tube wells or of the transmission mains and the water is being supplied through direct pumping into the distribution network.

There is no zoning in the existing distribution system. All areas connected to one reservoir are served in one go. Similarly distribution system directly fed from TWs is also supplied simultaneously. There is practically no chlorination system for disinfection of water supplied. The chlorination system wherever provided is either not functioning or highly undependable resulting in a high health risk.

0.1.1. EXISTING LEVEL OF SERVICE

Pop.	Transm. & Distr.		Population connected to Piped Water Supply		Water Storage / connected pop.		Distribution Network	
Cap.	2013 [m]	m/cap served	%	cap	2013 m³	m³/cap served	2013 [m]	m/cap served
468,614	159,376	0.91	37%	174,819	17,709	0.10	147,893	0.85

0.2. PROPOSED INTERVENTIONS

Following major interventions are proposed:

i Improve coverage of population by extending distribution system in uncovered areas.

ii Increase availability of water by augmenting existing water sources, improve operation and maintenance quality of pumping system, and reduce water losses.

iii Replace all old distribution pipe lines laid prior to 1982.

iv Introduce volumetric tariff, install consumer meters on all service connections, and bulk metering to monitor the Water Balance and allow early intervention in case of need.

v Introduce the preventive maintenance system of the assets.

vi Run the utility on commercial principles and ensure the sustainability of the capital investment.

vii Implement the Utility Monitoring System by Key Performance Indicators which allows clarity in decision making by the management.

viii Facilitate people in getting water connections easily to achieve larger coverage of population by water supply.

ix Turn illegally connected consumers into customers.

x Implement customer service to monitor and improve consumers' satisfaction by establishing customer service centres and consumer information and education campaigns.

0.3. PRESENT WATER CONSUMPTION HABIT

Many residents have developed compensatory strategies to overcome the low pressures and intermittent supplies including:

- storing municipal water in buckets and informal containers;
- storing municipal water in tanks (with or without pumps);

- rescheduling activities to coincide with the availability of water;
- obtaining water from tube wells;
- obtaining water from tankers (activity operated by the GWB or private contractors).

Specific problems of the current consumption habits include:

- serious risk to public health, resulting from ingress of contaminated groundwater into the distribution system;
- inability to practice effective supply management;
- inability to practice effective demand management;
- operational inadequacies, which unduly weaken the physical infrastructure;
- consumers' inconvenience.

0.4. DEMANDS

The water losses have been assumed by using experience based figures expressed in l/connection/day for systems that are developed randomly, without design, and are unmaintained. The result of the present Water Balance in Gaya is shown below:

Table 12: Water Balance for 2013 in Gaya

Description	2013
Domestic Demand [l/d]	23,164,400
Demand Floating Population [l/d]	8,400,000
Demand Hospitals [l/d]	84,000
Demand Schools [l/d]	803,000
Industrial Demand [l/]	1,870,000
Demand Livestock [l/d]	1,278,304
Conn. #	28,912
Specific Water loss value [l/conn/d]	700
Water Loss demand [l/d]	20,238,692
Total Demand [l/d]	55,838,396
Total Demand [MLD]	**55.84**
Total Demand [l/s]	**646.28**
Potential Water Production [MLD]	**68**
Water Loss [%] of production	**33%**
(+) Water Balance [MLD]	**12.16**

Result of Population Projections

Population Projection Method	Projected Population		
	2018	2033	2048
Exponential Graphical Method	524,297	675,237	848,200

Demand Projections

Description	2018	2021	2033	2048
Domestic Demand [l/d]	63,675,928	71,992,214	88,185,916	112,640,928
Demand Floating Population [l/d]	8,400,000	8,400,000	8,400,000	8,400,000
Demand Hospitals [l/d]	92,400	101,640	111,804	122,984
Demand Schools [l/d]	883,300	971,630	1,068,793	1,175,672
Industrial Demand [l/]	1,870,000	1,870,000	1,870,000	1,870,000
Demand Livestock [l/d]	1,278,304	1,278,304	1,278,304	1,278,304
Conn. #	87,053	120,689	147,837	188,617
Specific NRW value [l/conn/d]	150	160	170	200
NRW demand [l/d]	13,057,904	19,310,169	25,132,282	37,723,376
Total Demand [l/d]	89,257,836	103,923,957	126,047,099	163,211,264
Total Demand [MLD]	**89.26**	**103.92**	**126.05**	**163.21**
Total Demand [l/s]	**1,033.08**	**1,202.82**	**1,458.88**	**1,889.02**
Required Water Production [MLD]	**90**	**104**	**130**	**165**
NRW [%] of production	**15%**	**19%**	**19%**	**23%**
(+) Water Balance [MLD]	**0.74**	**0.08**	**3.95**	**1.79**

Projection of the Level of Service

Year	2018	2021	2033	2048
Pop Fully Plumbed	87%	95%	96%	98%
Pop. PSP	8%	4%	2%	1%
Pop. Served [%]	95%	99%	99%	99%
Total Pipe Length [m/cap.]	1.03	1.4	1.41	1.25
Distribution Network [m/cap.]	1.0	1.39	1.4	1.2
Storage [l/cap.]	60	50	50	50
NRW [l/conn/d]	150	160	170	200

0.5. PROPOSED CAPITAL INVESTMENT WORKS

Future capital investment works

Year	2018	2021	2033	2048
Tot. Water Supply Volume [MLD]	90	104	130	165
Laying of New Transmission Lines [m]	6848	2988	3586	10759
Laying of New Distribution Lines [m]	498332	244887	165050	135673
New service connections	87053	33636	114201	74416
New Storage volume to add [m³]	21440	1500	4000	5000

0.6. OPERATION AFTER COMPLETION OF 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

0.7. PROPOSED TYPE OF CONTRACT

In order to avoid the above bottlenecks the Consultant proposes a Performance Based Implementation Contract.

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.

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

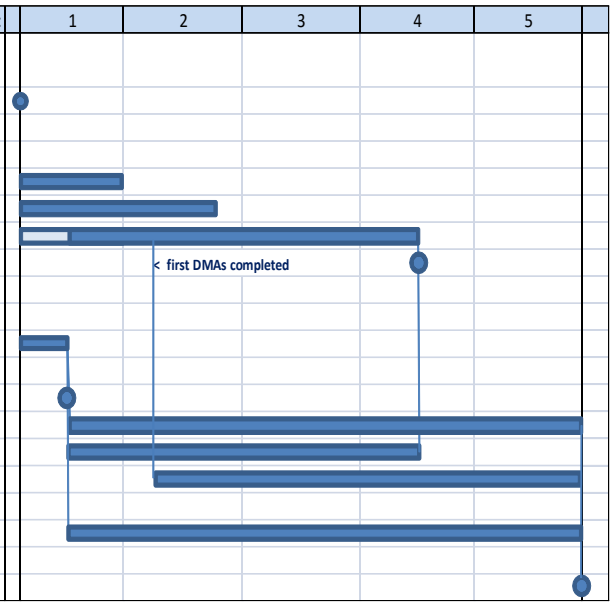
- One fixed Monthly Fee portion
- One portion based on meeting the Performance Criteria

The 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.

0.8. SCHEDULE OF IMPLEMENTATION

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**



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

1) Connections converted for 24x7 water supply system;
2) Reducing / maintaining low level of Non-Revenue Water;
3) Reducing energy consumption;
4) Maintaining water quality;
5) Maintaining terminal pressure in the distribution system;
6) Increasing revenue collection efficiency;
7) Customer complaint handling;
8) Development of Plans and Programs.

1. INTRODUCTION

Bihar is one of the major states in eastern India, being the third largest by population and twelfth largest by geographical area. The urban service delivery e.g. water supply, sewerage and solid waste management, etc. in the state are not adequate and are below the national and state benchmarks. The water supply lacks uniformity in improvement in terms of coverage, quantity and duration. The condition of these facilities in Gaya is not exceptional, indicating an immediate need of attention.

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1.1. PROJECT BACKGROUND

To accelerate the economic growth of Bihar, it is imperative to enhance the major urban services e.g. water supply, sewerage and solid waste management to achieve better health status of the urban population in the second to the fifth largest towns (Bhagalpur, Darbhanga, Gaya and Muzaffarpur) with economic growth potential. This will empower the four towns to unceasingly play their roles as the engines of economic evolution in Bihar.

The physical investment requirements to water supply, sewerage and Solid Waste Management sub-sectors in these four towns are estimated at about Rs 21 billion, Rs 11 billion and Rs 3 billion respectively under the Roadmap. Although the urban infrastructure development scheme for small and medium towns (UIDSSMT), the National Ganga River Basin Authority (NGRBA), and other national and state budgetary allocations are available, but are not adequate to meet the entire investment requirement.

In the light of the large financial requirements for the roadmap implementation in Bihar, ADB has agreed for a multi tranche financing facility (MFF) of $200 million for the Bihar Urban Development Investment Program (BUDIP).

The objective of the Bihar Urban Development Investment Program (BUDIP) is to improve the quality, coverage, and reliability of water supply and sewerage services for an estimated 1.5 million residents living in these four towns.

Bihar Urban Development Infrastructure Corporation (BUIDCo) is the implementing agency for investment program. It will engage and supervise contractors and consultants on behalf of the municipal corporations. In line with the requirements of the investment program, BUIDCo has selected **Shah Technical Consultants Pvt. Ltd.** in association with **IPE Global Pvt. Ltd. and**

Cogent Training Research Development Consultant Pvt. Ltd. as the Design Supervision Consultants.

1.2. PREVIOUS STUDIES AND SURVEYS

Few hydro-geological surveys were carried out in the past to assess the ground water potential and capability along the river Phalgu to use the river as the source of water for Gaya town. The details of these studies are as follows:

i. Central Ground Water Board (CGWB)

A study conducted by Central Ground Water Board (CGWB) in Year 1978 to assess the ground water potential and capability along the river Phalgu (in the river flood plain) recommends that tube wells in the bed of Phalgu river may be taken as a source for water supply for MES, as adequate yield of the tube wells is available in the bed. However, no detailed hydro geological study was carried out before coming to this conclusion.

ii. The WAPCOS report from December 2012

UDHD, GoB awarded the work of preparation of DPR for augmentation of water supply of Gaya town in 2010 WAPCOS. In this report it was assumed that underground water available in Phalgu basin will be adequate to meet water demand of the town until 2029 but gave no reasons or justification for this assumption.

iii. M/S Kirloskar Brothers Ltd. Kolkata

PHED, GoB is executing a project to augment water supply to Gaya town on behalf of Gaya Municipal Corporation. PHED awarded the work to M/S Kirloskar Bros. Ltd in 2008. The contractor constructed 8 tube wells in 2008-2009. The results of TWs constructed are summarized below:

Table 1: Tube wells report

No.	Location	Dia (mm)	Depth (m)	Discharge (lps)	Year of Inst.	Remarks
1	Dandibagh TW 5	300	22	28	2008	Soft rock which is bed rock found at depth of 23m BGL
2	Muffassil Thana (Manpur)	450	27	82	2008	Hard rock at the depth of 27m BGL
3	Janakpur-Near Bridge (Manpur)	300	30	32	2008	-
4	Near Jora Masjid Khanjhapurroad (Manpur)	450	33	78	2008	Hard rock at 33m depth BGL
5	Dandibagh TW1	450	108.23	47	2008	Hard rock at Depth of 108.23m BGL
6	Dandibagh TW2	450	22.85	47	2008	Hard rock at Depth of 22.85m BGL
7	Dandibagh TW3	450	21.95	47	2008	Hard rock at Depth of 21.95m BGL
8	Dandibagh TW4	450	22.5	47	2008	Hard rock at Depth of 22.5m BGL

iv. Hydro-Geosurvey Consultants Private Limited (HGCPL)

HGCPL is conducted comprehensive hydrogeological investigations, and it is concluded that there is no need of getting water from Ganga river as the Phalgu river in itself is a boon for Gaya town for meeting its water requirement of 124 MLD by considering dry weather duration of 75 days where

water requirement is 163 MLD and dry weather duration may by 4 months. The consultants also not identified the pin pointing of proposed tube wells.

It is essential to undertake a detailed hydro geological study to determine the extent of the basin, its characteristics and its potential to provide sustained discharge for city water supply over a long period of time.

DSC had prepared detailed ToR and eventually contracted work for conducting the resistivity survey. The main objective of the survey & investigation is to pinpoint the Tube well locations using Geophysical (Resistivity) and Geo hydrological survey & investigation. And the study is conducted along both banks of River Phalgu and in Gaya Municipal Corporation. The detailed survey and investigations are provided in package-2.

1.3. BASE OF THE DPR

The objective of the present DPR is to define the measures needed in Gaya for improving in a sustainable manner the water supply to the population except for additional water requirement to meet projected demand for design year 2048.

A planning based on the analysis of the present situation was until this report not performed for the water supply system of Gaya. However by the time this report was submitted, under the present BUDIP, a SAR containing an EIA was under preparation by the Project Management Consultant, based on their own investigations and on investigations and analysis prepared by the Design and Supervision Consultant. Due to shortage of time the preparation and collection of following data and analysis were not performed:

- Hydro-geological investigations;
- Mapping of properties and service connections;
- Ground truthing of existing distribution network;
- Social awareness and acceptance campaign;
- Energy Audit;
- Flow and pressure measurements at consumers' connections.

The following activities were undertaken in the process of preparing present report:

- Study of report prepared by WAPCOS;
- Census 2011 and population projections as described further;
- Collection of existing system drawings and plans from the period before 1982;
- Collection of projects and drawings prepared during the last 7 years or under implementation by PHED;
- Collection of data ward wise on number of households, water connections, schools, hospitals, floating population, small industries, and livestock;
- Study of existing social reports;
- Location pinpointing of existing water production and storage facilities by means of GPS;
- Recording the data of the equipment installed at the production facilities;
- Bulk Flow measurement campaign at production and storage facilities by means of ultra-sonic flow meters;
- Water quality analysis by PHED on the request of the Consultant;
- Analysis of present level of service based on above activities and projection of future level of service;

- Projection of Demand including migration of the type of connections;
- Conceptual design of District Metered Areas in view of the future operation of the system;
- Hydraulic modeling of the proposed water distribution network;
- Definition of storage capacities for the project horizon:
- Generating the Unit Prices Data Base from enquiries, and ongoing projects in the area or elsewhere in India.
- Mapping of all collected and produced information on the geo-rectified satellite image provided by the Urban Development and Housing Department – as AutoCAD and shape file formats;
- Preparation of Standard Designs.
- Preparation of Cost Estimates per component.

1.4. SCOPE OF THE DPR

The above activities lead to the defining the scope of the DPR comprising the following:

1. to provide for refurbishment of existing ground water sources and their pumping machinery;
2. optimize the extracted volume of water from the aquifer;
3. provide for additional service reservoir capacity to meet the projected demand for the design year 2048;
4. rehabilitation/replacement of existing distribution pipe lines designed to comply with the demand of the Gaya population by 2048;
5. extension of the distribution network to the presently uncovered areas;
6. formation of appropriate District Metering Areas (DMAs) to allow for appropriate monitoring of water distribution and NRW on routine basis;
7. to achieve a NRW level less than 20% by year 2021;
8. refurbish/replace existing service connections and provide new consumer connections;
9. provide all consumers' connections with good quality water meters, AMR compatible;
10. operate and maintain the system for a period commencing after takeover of the assets by the contractor until 4 (four) years after completion of construction work;
11. provide conditions for implementing preventive maintenance;
12. Provide conditions for forming a new water operation unit under GMC and for capacity building of this unit to operate under economic conditions.

1.5. STRUCTURE OF THE DPR

DPR is presented in following four volumes:

Volume I:	General Report
Volume II:	Network hydraulic design
Volume III:	Drawings
Volume IV:	Confidential Cost Estimates including unit rates

In the various chapters of the Volume I we are presenting the results according to the following logical sequence:

- background of the project,
- the sources of information used,

- diagnostics of the existing water supply system,
- the proposed measures,
- the information about the methodology used for designing the mentioned measures.

The Chapter 0 “Executive Summary” is meant for condensing the information on the input and on outcome of the present report.

2. EXISTING WATER SUPPLY SYSTEM

The piped water supply system in Gaya town was introduced in 1924 with Phalgu River as a source of water. Later in the year 1954–55, a ground water based water supply system was developed at Dandibagh, on the bank of river Phalgu due to inadequate flow in the river during summer and it's incapability to cope with the growing water demand of the town. The water supply system was extended to different parts of the town from time to time.

Government of India sanctioned a project under 12th Finance Commission program to augment water supply of the city at an estimated cost of Rs.11.94 Crores in 2007. This project involved construction of battery of Tube Wells on the bank of river Phalgu near Dandibagh and also in various parts of the city to increase water production by 16 MLD and provide distribution system for the newly developed areas like Manpur, AP Colony etc. The work on this project is being executed by Public Health Engineering Department of GoB on behalf of Gaya Municipal Corporation (GMC) and is in advanced stage of completion.

2.1. SERVICE COVERAGE

The town is located on the Banks of River Phalgu at a height of about 110 m above mean sea level (msl). The river Phalgu flows from south to north of the town stretching a width of about 900 m. According to Census 2011, the population in Gaya Municipal area was 468614 spreading over an area of 48.517 km^2.

Gaya is governed by Municipal Corporation. From administrative point of view the town has been divided in 53 wards of which ward no. 47, 48, 49, 50, 51, 52 and 53 lie in Manpur area situated on the right bank of River Phalgu.

About two thirds of the total area of 4852 ha is urbanised. The existing water supply system is not covering the entire urbanised area. DSC's investigations have shown that a large proportion of the population connected to the piped water supply system is not using it due to unreliable water quality and/or intermittent supply and prefers to use private wells.

A summary of data collected from wards counsellors is shown in the Table 2 hereafter:

Table 2: Present Service Coverage

Ward	Number House Holds	Served House Holds	2013 HH FP	FP %	HH served from PSP	PSP %	Served %
1	1544	65	50	3%	15	1%	4%
2	1296	275	200	15%	75	6%	21%
3	2098	75	50	2%	25	1%	4%
4	2019	250	100	5%	150	7%	12%
5	576	460	460	80%		0%	80%
6	2057	800	800	39%		0%	39%
7	1279	655	600	47%	55	4%	51%
8	1764	100	100	6%		0%	6%
9	858	150	150	17%		0%	17%
10	1318	550	550	42%		0%	42%
11	1017	260	100	10%	160	16%	26%
12	1780	600	600	34%		0%	34%
13	675	370	370	55%		0%	55%
14	1668	100	100	6%		0%	6%
15	1245	700	700	56%		0%	56%
16	1182	420	300	25%	120	10%	36%

Ward	Number House Holds	Served House Holds	2013 HH FP	FP %	HH served from PSP	PSP %	Served %
17	1048	700	700	67%		0%	67%
18	718	260	260	36%		0%	36%
19	793	420	420	53%		0%	53%
20	732	500	500	68%		0%	68%
21	369	155	100	27%	55	15%	42%
22	1283	700	700	55%		0%	55%
23	1023	100	100	10%		0%	10%
24	880	350	350	40%		0%	40%
25	1489	350	350	24%		0%	24%
26	1078	470	470	44%		0%	44%
27	2539	870	870	34%		0%	34%
28	1549	450	450	29%		0%	29%
29	1456	1100	1100	76%		0%	76%
30	2503	900	900	36%		0%	36%
31	1287	250	250	19%		0%	19%
32	1262	1060	1000	79%	60	5%	84%
33	800	360	360	45%	0	0%	45%
34	1607	570	570	35%		0%	35%
35	741	400	400	54%		0%	54%
36	1930	690	690	36%		0%	36%
37	593	450	450	76%		0%	76%
38	1554	650	650	42%		0%	42%
39	889	460	460	52%		0%	52%
40	1227	600	600	49%		0%	49%
41	1023	458	400	39%	58	6%	45%
42	1129	500	500	44%		0%	44%
43	1491	370	370	25%		0%	25%
44	866	700	700	81%		0%	81%
45	1982	900	900	45%		0%	45%
46	1422	550	550	39%		0%	39%
47	1180	700	700	59%		0%	59%
48	1968	850	850	43%		0%	43%
49	2110	750	750	36%		0%	36%
50	2477	1126	1100	44%	26	1%	45%
51	1305	70	70	5%		0%	5%
52	1716	700	700	41%		0%	41%
53	1723	650	650	38%		0%	38%
Totals	**72118**	**26969**	**26170**	**36%**	**799**	**1%**	**37%**

2.2. AVAILABLE SOURCES OF WATER

The water sources of Gaya consist of underground water extracted by tube wells located on both sides of the River Phalgu, Manpur and Gaya main. There are 39 tube wells in the town at present of which one is meant for fire fighting, one has become defunct and 2 are standby.

The tube wells are in 4 segments, i.e. Manpur side, Dandibagh side, Panchayati Akhara side and within the main city area. The tube wells in Manpur, Dandibagh and Panchayati Akhara area are bored in the bed/bank of river Phalgu and the other tube wells are bored at various locations in the town, away from the river bank. The tube wells constructed in Manpur side are pumping directly to distribution system in Manpur area. The tube wells constructed in Dandibagh side are used to pump water to the reservoirs located on Brahmayoni hills. Tube wells locate in Panchayati Akhara are used to pump water to the reservoirs located on Ramshila hills and Murlihillls. The tube wells installed in the town area are used to pump water directly to the distribution system.

The WAPCOS report refers to the high potential of the aquifer underlying the Phalgu River upstream of Gaya, towards Bodhgaya in the south. In that area the river flows through a wide plain. At Gaya the width is reduced with rocky outcrops on both the East and West banks. Near Gaya the depth to the rock underlying the alluvial deposits is in the order of 25 to 30m only. It is possible that further upstream, and with a widening of the alluvial plain, the depth-to-rock is more, resulting in a wider and maybe deeper aquifer.

It is assumed that the wells currently installed at Dandibagh extract water from a relatively small sub-aquifer, resulting in the limited recharge as experienced at the existing wells. The relatively small distance between the existing wells may also play a role.

The Consultant has performed a flow measurement campaign at all tube wells in Gaya and the results are shown in the Table 3 hereafter. During the flow measurement campaign the pumps were working for long periods. No drop in the capacity of the wells has been reported. For this reason the total water production of the tube wells in Gaya can be considered as the sum of the yield of all wells.

Table 3: Present Water Production

ID	Name	Discharge informed by GMC m^3/h	Power Availability h	No. of Running hours	Measured Flow	
					m^3/h	m^3/d
1	Dandibagh No. 1#	NA	23	22	0	0
2	Dandibagh No. 2	250	23	22	225	4950
3	Dandibagh No. 3	250	23	22	172	3794
4	Dandibagh No. 4	250	23	22	186	4094
5	Dandibagh No. 5	250	23	22	4	88
6	Panchayati Akhara No. 1	68	20	20	104	2083
7	Panchayati Akhara No. 2	41	20	20	94	1888
8	Azad Park	54	20	11	52	572
9	Dhobighat	45	20	11	37	407
10	Central School	54	20	8	79	632
11	Nigam Store	54	20	5	23	115
12	Gurudwara	54	20	10	56	560
13	Fire Station	36	20	8	55	440
14	New Godown	54	20	11	50	550
15	Kharkhus	41	20	12	46	552
16	Delha	27	20	8	45	360
17	Panchayati Akhara No. 3#	68	20			0

ID	Name	Discharge informed by GMC m³/h	Power Availability h	No. of Running hours	Measured Flow	
					m³/h	m³/d
18	Janata Colony	14	20	9	39	351
19	Janata Colony	14	20	12	18	216
20	Pilgrim Hospital	14	20	5	17	85
21	Visnupad	73	20	8	129	1032
22	Bypass	27	20	8	80	640
23	Bairagi Powerganj	32	20	6	79	474
24	Bageshwari Pachim	14	20	8	19	152
25	Pitamaheshwar	54	20	5	65	325
26	Kauvasthan	32	20	8	17	136
27	Hata Godown	54	20	8	52	416
28	Manpur	54	20	10	93	930
29	Manpur - Buniydiganj	68	20	11	65	715
30	Khadi Gramodyog Lakhibagh	54	20	20	53	1067
31	Cotton Mill ##					
						27624

#Flow could not be measured due to pump break down

TW not functional

Table 3 further shows that the existing TWs are highly underutilised both from rate of pumping as well as operational hours points of views. The present total daily production works out to 27624 m³/day only.

There are 31 TWs owned by GMC of which 30 are under operation. In addition to these, PHED has constructed 8 TWs on behalf of GMC of which 4 have been commissioned. Two TWs constructed by PHED are proposed to be used as standby tube wells. The status of installed equipment and their condition on Tube Wells is shown in the Table 4 below:

Table 4: Tube Wells Equipment Condition

ID	Name	Transformer		In Operation	Remark
		kVA	Available		
1	Dandibagh No. 1	500 & 300	Yes	Yes	Pump no 1 will be installed after replacing with 125 hp pump-2
2	Dandibagh No. 2			Yes	Will be changed with 125 hp motor, No room for pump
3	Dandibagh No. 3			Yes	Poor condition of electrical equipment , No room for pump
4	Dandibagh No. 4			Yes	Poor condition of electrical equipment
5	Dandibagh No. 5			Yes	Poor condition of electrical equipment
6	Panchayati Akhara No. 1	200	Yes	Yes	Needs maintenance(new starters provided of electrical systems)
7	Panchayati Akhara No. 2			Yes	Needs maintenance(new starters provided) of electrical system

ID	Name	Transformer		In Operation	Remark
		kVA	Available		
8	Azad Park	200	Yes	Yes	Below OHLR, Needs maintenance of electrical system
9	Dhobighat	100	Yes	Yes	Poor condition of Electric system
10	Central School	200	No	Yes	Poor condition of Electric system
11	Nigam Store	200	Yes	Yes	Valve not visible, no proper approach
12	Gurudwara	100	Yes	Yes	Poor condition of Electrical system
13	Fire Station	200	No	Yes	Poor condition of Electric system
14	New Godown	100	Yes	Yes	No proper approach, needs maintenance
15	Kharkhus	250	Yes	Yes	Needs maintenance for electrical equipment
16	Delha	63	No	Yes	Poor Condition of Electrical system
17	Panchayati Akhara No. 3	63		No	Poor Condition, Pump out of order
18	Janata Colony	200	No	Yes	Needs maintenance of Electric system
19	Janata Colony	100	No	Yes	New constructed, cabling laid above floor
20	Pilgrim Hospital	100	Yes	Yes	Poor condition of Electrical system
21	Visnupad	63	Yes	Yes	Needs maintenance
22	Bypass	100	Yes	Yes	Needs maintenance for stators & pumps
23	Bairagi Powerganj	63	Yes	Yes	Poor condition of electrical system
24	Bageshwari Pachim	63	Yes	Yes	Needs maintenance
25	Pitamaheshwar	100	Yes	Yes	Needs maintenance
26	Kauvasthan	63	Yes	Yes	Poor condition of Electric system
27	Hata Godown	200	No	Yes	Poor condition of Electric system
28	Manpur	100	Yes	Yes	Pumps operated by local people also.
29	Manpur - Buniydiganj	100	Yes	Yes	Pump house to be repaired
30	Khadigramodyog Lakhibagh	300	Yes	Yes	Needs maintenance
31	Cotton Mill				Not functional
32	New TW Kirloskar-1			Yes	
33	New TW Kirloskar-2			Yes	
34	New TW Kirloskar-3			No	
35	New TW Kirloskar-1	500	Yes	Yes	New constructed
36	New TW Kirloskar-2			Yes	New constructed
37	New TW Kirloskar-3			No	Not commissioned
38	New TW Kirloskar-4			No	Not commissioned
39	New TW Kirloskar-5	63	Yes	No	Not commissioned

There is practically no instrumentation available at Tube Wells like electric measuring instruments (ampere meters, volt meters, energy meters, power factor meters etc.), pressure gauges, flow meters, water level measuring instruments etc. In absence of required instrumentation, the present level of production and performance level of electro-mechanical equipment is not known.

The water pumped from the tube wells is directly pumped to the service reservoirs or to the distribution system without any disinfection as no chlorination system has been provided on tube wells or on service reservoirs.

2.3. THE EXISTING WATER DISTRIBUTION SYSTEM

The existing distribution system is not in conformity with basic engineering practices. Part of it consists of Transmission Mains raising the water to 1 Over Head Tank and 7 Ground Level Reservoirs on hills. The other part is operated by pumping the Tube Wells water directly into the

distribution network. For this portion no storage capacities are available. A layout of the existing distribution system is presented in the Drawing No.1

2.3.1. RISING MAINS

There are three Cast Iron rising mains 350 mm, 450 mm and 600 mm of 1.6 km length each from Dandibagh to Brahmayoni Hills reservoirs. One more DI rising main 450 mm of 2.3 km length has been laid recently under the augmentation project under 12th Finance Commission program from Dandibagh to Shringsthan GLSR.

2.3.2. EXISTING STORAGE CAPACITIES

The status of existing storage reservoirs and their health is depicted in **Table 5**.

Table 5: Existing Storage

ID	Location/Name	Capacity [m³]	Age	Staging	Health	Comment
6	Ramshila Hills	227	50+ years old	No	Bad	Very low capacity
8a	Murli Hills	1630	50+ years old	No	Bad	Roof and inside wall need repair
9	Ajad Park	454	50+ years old	12.2 m	Workable	Needs slight repair from inside
10a	Brahmayoni	1816	70+ years old	No	Bad	Roof and inside wall in very bad condition and need replacement
10b	Brahmayoni	1816	70+ years old	No	Bad	
11	Brahmayoni	3632	50+ years old	No	Workable	Needs slight repair from inside
12	Brahmayoni	3632	50+ years old	No	Workable	
13a	Shringh Sthan	4540	2013	No	Workable	Although recently constructed, it leaks from various places

Note: The ID corresponds to the marking on the Drawing mentioned above.

The total existing storage capacity is of 17747 m³.

The reservoirs constructed on Ramshila hills, Murli hills and overhead tank at Azad Park are not functional at present as these tanks are not being fed due to inadequate capacity of the pumping plants on respective tube wells or of the transmission mains and the water is being supplied through direct pumping into the distribution network.

2.3.3. EXISTING DISTRIBUTION NETWORK

The Table 6 and Table 7 summarize the length of the existing distribution network sorted by diameter and by origin respectively:

Table 6: Existing Distribution Network Data

Description	Length [km]	Dia. [mm]	Length [m]
PHED		100	39684
		150	16422
		200	15788

Description	Length [km]	Dia. [mm]	Length [m]
		250	2050
		300	981
		350	2140
		400	5235
	85	450	2594
		Sub-Total	84894
Before 1982		50	436
		63	3930
		75	10952
		100	8065
		125	9166
		150	12790
		175	2633
		200	6986
		225	253
		250	3811
		300	2728
		400	2325
	65	600	645
		Sub-Total	64722
Total	**150**		**149616**

Table 7: Length of distribution network sorted by diameter

Length [Km]	Dia. [mm]	Length [m]
	50	436
	63	3930
	75	10952
	100	47749
	125	9166
	150	29212
	175	2633
	200	22773
	225	253
	250	5861
	300	3710
	350	2140
	400	7560
	450	2594
	600	645
150	**Total**	**149616**

There is no zoning in the existing distribution system. All areas connected to one reservoir are served in one go. Similarly distribution system directly fed from TWs is also supplied simultaneously. There is practically no chlorination system for disinfection of water supplied. The chlorination system wherever provided is either not functioning or highly undependable resulting in a high health risk.

It has to be mentioned at this stage that most of the pipelines laid by PHED have not been handed over to GMC but are presently in use.

2.3.4. CONSUMERS' CONNECTIONS

There are around 12500 registered consumers in the town. However, there is large number of unauthorised and unidentified consumers connected to the distribution system. According to the information collected from Wards Counsellors, the total number of connections is about 29000. There is no metering of water supplied to consumers and no water billing system. Water charges are levied as part of the Holding Tax on properties by the GMC.

The identified categories of existing consumer connections are the following:

i. Domestic Connections composed of House Connection considered as Fully Plumbed (FP) and Public Stand Posts (PSP);

ii. Institutional connections (Schools, Hospitals, etc.)

iii. Hostels and floating population supply points

iv. Industries (small scale)

At present there are 1074 Public Stand Posts in the town which are being used by people not connected with individual connections for domestic purposes. Not all are functional and the number of households using them has been collected from the wards counsellors.

A summary of above types of connections identified ward wise is presented below in the Table 8:

Table 8: Number of Connections in Gaya

Ward	Domestic	Floating & Hostels	Hospitals	Schools	Industries	Totals
1	50			4		55
2	200			6		207
3	50			15		66
4	100			25		128
5	460					461
6	800			10		811
7	600	6		9		616
8	100			2		103
9	150			5		156
10	550					551
11	100			5		108
12	600		1			602
13	370					371
14	100			10		111
15	700					701
16	300	6		4		312
17	700			4		705
18	260		1	5		267
19	420			11		432
20	500			3		504
21	100			0		101
22	700					701

Ward	Domestic	Floating & Hostels	Hospitals	Schools	Industries	Totals
23	100		1	11		113
24	350					351
25	350					351
26	470			10	1 Milk	482
27	870					871
28	450			5		456
29	1100					1101
30	900					901
31	250					251
32	1000			7		1008
33	360	4		7		372
34	570					571
35	400					401
36	690	5				696
37	450	5				456
38	650	4				655
39	460	4				465
40	600	15				616
41	400	10		6		417
42	500			4		505
43	370			5		376
44	700					701
45	900	10				911
46	550			4	200 dyeing	755
47	700			5		706
48	850			6	1000 dyeing	1857
49	750			5	1200 dyeing	1956
50	1100			8		1109
51	70			2		73
52	700			9		710
53	650					651
Totals	**26170**	**69**	**3**	**212**	**2401**	**28912**

2.4. RECENT AND ONGOING CONSTRUCTION WORKS

Government of India sanctioned a project under 12th Finance Commission program to augment water supply of the town at an estimated cost of Rs.11.5 Crores in 2007. This project involved construction of battery of Tube Wells on the bank of river Phalgu near Dandibagh and also in various parts of the town to increase water production by 16 MLD and provide distribution system for the newly developed areas like Manpur, AP Colony, etc. The work on this project is being executed by Public Health Engineering Department of GoB on behalf of Gaya Municipal Corporation (GMC) and is in advanced stage of completion. The highlights of the works as communicated by PHED are as follows:

i. Transformers – Out of total 5 installed 3 are complete

ii. 8 nos. of tube wells – Complete

iii. 8 nos. of Pump houses on tube wells – Complete

iv. Pumps and motors – 8 nos. provided, 1 currently working

v. Rising Mains – laying of 2500m complete

vi. Gravity Mains – laying of 3433m out of total 4000m complete, the works of Sluice Valves and sluice valve chambers are 50% complete

vii. Service reservoir – Complete

viii. Distribution Network – Out of proposed total 84894 m the length laid is 47966 m. large portion of the total length laid was not handed over to GMC.

3. EXISTING LEVELS OF SERVICE

There is no national or regional benchmarking in place and there is no comprehensive assessment of sector performance by which inter-utility comparisons can be made. At the macro-level, the region lacks the benefit of having access to data and statistics on water demand and on water supply. Therefore benchmarking and sharing of data among the partners will greatly improve the availability of information and transparency in the sector.

The International Water Association (IWA) briefly defines benchmarking as “a tool for performance improvement through systematic search and adaptation of leading practices” and is therefore not a single action but a continuous, cyclical process. The data on performance of the water utilities is gathered and available with IBNET affiliated to IWA. The Key Performance Indicators for water utilities are also available with IBNET.

The benchmarking is intended to be the initial step in a long term initiative to improve the performance of the urban water supply scheme of Gaya town to enable the authorities to take policy decisions for water infrastructure development and improvement in service delivery through judicious mobilization of scarce resources. It is recommended that GMC establish a system of annual benchmarking of the Gaya water supply scheme.

The present situation, base for projecting further improvements, is shown in the Table 9 below:

Table 9: Indicators of Present Level of Service

Ward	Population	Transmission. & Distribution		Population connected to Piped Water Supply		Water Storage / connected population		Distribution Network	
	Cap.	2013 [m]	m/cap served	%	cap	2013 m³	m³/cap served	2013 [m]	m/cap served
1	9,398	80	0.20	4%	396			62	0.16
2	8,264	991	0.57	21%	1,754			910	0.52
3	12,881	742	1.61	4%	460			721	1.57
4	13,015	517	0.32	12%	1,612	76	0.05	443	0.27
5	3,734	155	0.05	80%	2,982	76	0.03	17	0.01
6	13,776	1,239	0.23	39%	5,358	76	0.01	990	0.18
7	8,676	1,828	0.41	51%	4,443	454	0.10	1,623	0.37
8	10,714	1,129	1.86	6%	607	454	0.75	1,101	1.81
9	5,741	1,198	1.19	17%	1,004	265	0.26	1,151	1.15
10	8,219	1,447	0.42	42%	3,430	265	0.08	1,288	0.38
11	6,779	1,168	0.67	26%	1,733	265	0.15	1,088	0.63
12	10,526	1,627	0.46	34%	3,548	265	0.07	1,462	0.41
13	4,134	582	0.26	55%	2,266	454	0.20	477	0.21
14	10,474	1,849	2.94	6%	628	454	0.72	1,819	2.90
15	7,279	1,734	0.42	56%	4,093	454	0.11	1,545	0.38
16	6,901	1,326	0.54	36%	2,452	265	0.11	1,213	0.49
17	6,422	2,858	0.67	67%	4,290	265	0.06	2,660	0.62
18	4,365	1,717	1.09	36%	1,581	454	0.29	1,644	1.04
19	5,139	833	0.31	53%	2,722	454	0.17	707	0.26

Ward	Population	Transmission. & Distribution		Population connected to Piped Water Supply		Water Storage / connected population		Distribution Network	
	Cap.	2013 [m]	m/cap served	%	cap	2013 m³	m³/cap served	2013 [m]	m/cap served
20	4,576	2,744	0.88	68%	3,126	454	0.15	2,600	0.83
21	2,700	359	0.32	42%	1,134	454	0.40	306	0.27
22	8,869	591	0.12	55%	4,839	404	0.08	367	0.08
23	7,187	4,084	5.81	10%	703	404	0.58	4,052	5.77
24	6,636	2,834	1.07	40%	2,639	404	0.15	2,712	1.03
25	10,346	9,752	4.01	24%	2,432	504	0.21	9,640	3.96
26	7,003	10,720	3.51	44%	3,053	504	0.17	10,578	3.46
27	15,984	2,944	0.54	34%	5,477	504	0.09	2,690	0.49
28	10,663	143	0.05	29%	3,098	504	0.16		
29	8,407	1,150	0.18	76%	6,351	504	0.08	856	0.13
30	15,981	27,240	4.74	36%	5,746	504	0.09	26,973	4.69
31	8,804	327	0.19	19%	1,710	504	0.29	248	0.14
32	7,402	16,519	2.66	84%	6,217	504	0.08	16,231	2.61
33	5,195	425	0.18	45%	2,338	504	0.22	317	0.14
34	10,865	1,476	0.38	35%	3,854	519	0.13	1,297	0.34
35	4,990	1,351	0.50	54%	2,694	519	0.19	1,226	0.46
36	12,581	1,062	0.24	36%	4,498	519	0.12	854	0.19
37	3,678	442	0.16	76%	2,791	519	0.19	312	0.11
38	10,574	2,350	0.53	42%	4,423	519	0.12	2,145	0.49
39	5,535	2,314	0.81	52%	2,864	519	0.18	2,182	0.76
40	8,584	1,115	0.27	49%	4,198	404	0.10	920	0.22
41	6,747	4,003	1.33	45%	3,021	404	0.13	3,863	1.28
42	7,399	2,704	0.83	44%	3,277	519	0.16	2,552	0.78
43	10,175	1,045	0.41	25%	2,525	404	0.16	928	0.37
44	5,800	2,376	0.51	81%	4,688	404	0.09	2,159	0.46
45	12,501	6,471	1.14	45%	5,677	404	0.07	6,208	1.09
46	9,344	395	0.11	39%	3,614	404	0.11	228	0.06
47	7,974	2,740	0.58	59%	4,730			2,521	0.53
48	13,521	3,085	0.53	43%	5,840			2,815	0.48
49	15,482	5,872	1.07	36%	5,503			5,617	1.02
50	15,587	4,787	0.68	45%	7,086			4,459	0.63
51	8,487	779	1.71	5%	455			758	1.67
52	10,972	4,462	1.00	41%	4,476			4,255	0.95

Ward	Population	Transmission. & Distribution		Population connected to Piped Water Supply		Water Storage / connected population		Distribution Network	
	Cap.	2013 [m]	m/cap served	%	cap	2013 m^3	m^3/cap served	2013 [m]	m/cap served
53	11,628	4,306	0.98	38%	4,387			4,103	0.94
Totals	**468,614**	**159,376**	**0.91**	**37%**	**174,819**	**17,709**	**0.10**	**147,893**	**0.85**

3.1. PRESENT WATER QUALITY

As part of the Environmental Assessment of Gaya water supply project-package-2, water sampling is done on 15 June 2015 and the laboratory analysis was carried out by SGS India Pvt. Ltd. Under contract with PMC. The results are shown in Table 4 and Table 5. With the results, it is concluded that the water currently abstracted from the aquifer to be used for this water supply project is safe for drinking.

Table 10 Results for production tube wells

S. No.	Parameters	Location		Standard : IS 10500:2012	
		1. Panchayati Akhara	2. Dandibagh		
	Physicochemical			Acceptable	Permissible
1	BOD (27°C for 3days) mg/L	BDL	BDL	-	-
2	COD mg/L	<5.0	<5.0	-	-
3	Calcium as Ca mg/L	56.7	26.7	75	200
4	Chloride as Cl mg/l	55.8	14.0	250	1000
5	Residual free Chlorine mg/L	BDL	BDL	0.2	1
6	Colour in Hazen unit	10	10	5	15
7	Fluoride as F mg/L	0.3	0.3	1.0	1.5
8	Total hardness as CaCo3 mg/L	210.1	99.0	200	600
9	Mg mg/L	16.7	7.9	30	100
10	Nitrate as NO3 mg/L	5.29	2.20	45	No relaxation
11	pH at 25°C	7.58	7.84	6.5-8.5	No relaxation
12	Sulphates as SO4 mg/L	9.6	6.3	200	400
13	TDS mg/L	311.2	165.6	500	2000
14	Arsenic as As mg/L	BDL	BDL	0.01	0.05
15	Total Chromium as Cr mg/L	BDL	BDL	0.05	No relaxation

16	Cu mg/L	BDL	BDL	0.05	1.5
17	Pb mg/L	0.010	BDL	0.01	No relaxtion
18	Mn mg/L	BDL	BDL	0.1	0.3
19	Cd mg/L	BDL	BDL	0.003	-
20	Amoniacal Nitrogen as N mg/L	BDL	BDL	-	-
21	DO mg/L	3.4	4.5	-	-
22	Conductivity as 25°C µS/cm	497	266	-	-
23	Oil and Grease mg/L	BDL	BDL	-	-
24	Fe mg/L	0.06	0.07	0.3	No relaxation
25	Zn mg/L	0.02	0.02	5	15
26	Na mg/L	47.49	21.28	-	-
27	K mg/L	2.78	BDL	-	-
28	Total Phosphates as PO4 mg/L	0.37	BDL	-	-
29	TSS mg/L	BDL	BDL	-	-
30	Temperature °C	30.6	30.5	-	-
	Pesticides				
1	Methyl parathion µg/L	<0.01	<0.01	-	0.3
2	Malathion µg/L	<0.01	<0.01	-	190
3	Chlorpyriphos µg/L	<0.01	<0.01	-	30
4	DDT (o,p and p,p isomers of DDT DDE and DDD) µg/L	<0.01	<0.01	-	1
5	Gamma HCH µg/L	<0.01	<0.01	-	2
6	Alpha HCH µg/L	<0.01	<0.01	-	0.01

7	Beta HCH µg/L	<0.01	<0.01	-	0.04
8	Delta HCH µg/L	<0.01	<0.01	-	0.04
9	Endosulfan Sulphate (Alpha Beta and sulphate) µg/L	<0.01	<0.01	-	0.4

Table 11: Results for groundwater underlying agriculture fields

S. No.	Parameters	Location		Standard : IS 10500:2012	
		3. Khiriyawa village	4. Amwan village		
	Pesticide residue			**Acceptable**	**Permissible**
1	Melthyl parathion µg/L	<0.01	<0.01	-	0.3
2	Malathion µg/L	<0.01	<0.01	-	190
3	Chlorpyriphos µg/L	<0.01	<0.01	-	30
4	DDT (o,p and p,p isomers of DDT DDE and DDD) µg/L	<0.01	<0.01	-	1
5	Gamma HCH µg/L	<0.01	<0.01	-	2
6	Alpha HCH µg/L	<0.01	<0.01	-	0.01
7	Beta HCH µg/L	<0.01	<0.01	-	0.04
8	Delta HCH µg/L	<0.01	<0.01	-	0.04
9	Endosulfan Sulphate (Alpha Beta and sulphate) µg/L	<0.01	<0.01	-	0.4

3.2. SERVICE GAP ANALYSIS AND CRITICAL INTERVENTIONS

There is no effective system for water disinfection before supply resulting in high health risk. Established system for quality control of water supplied does not exist and the corporation depends on occasional check of water quality by the local laboratory of PHED, equipped for rural water supply.

There is a defined system for recording, disposal and supervision of consumer complaints under GWB but it is required to be more disciplined as the officials responsible for this purpose are sometimes unavailable during working days/hours. The consumer complaints normally relate to leakage or bursting of pipe line or no-supply. These complaints are normally conveyed personally or through telephone. However, a proper record is kept about the complaints, their nature, action taken and consumer satisfaction must be properly managed.

As no water charge recovery system is in place, cost recovery is considered as zero. As mentioned above, water charges are deemed to have been recovered as part of property tax (Holding tax). The efficiency of property tax collection is quite poor and stands at 64%, 41% and 48 % for the financial years 2011-12, 2010-11 and 2009-10 respectively.

Following major interventions are proposed:

i Improve coverage of population by extending distribution system in uncovered areas.

ii Increase availability of water by augmenting existing water sources, improve operation and maintenance quality of pumping system, and reduce water losses.

iii Replace all old distribution pipe lines laid prior to 1982.

iv Introduce volumetric tariff, install consumer meters on all service connections, and bulk metering to monitor the Water Balance and allow early intervention in case of need.

v Introduce the preventive maintenance system of the assets.

vi Run the utility on commercial principles and ensure the sustainability of the capital investment.

vii Implement the Utility Monitoring System by Key Performance Indicators which allows clarity in decision making by the management.

viii Facilitate people in getting water connections easily to achieve larger coverage of population by water supply.

ix Turn illegally connected consumers into customers.

x Implement customer service to monitor and improve consumers' satisfaction by establishing customer service centres and consumer information and education campaigns.

3.3. CURRENT WATER CONSUMPTION

3.3.1. PRESENT NEGATIVE WATER CONSUMPTION HABITS

Gaya has registered high population growth and has high water losses in the system that has resulted in exceeding the total water demand compared to available production capacity. To limit total demand and provide an equitable distribution of available water, the GWB have instituted intermittent or scheduled water services and reduced system pressures. Hours of available supply vary, depending on location in the system, from nearly continuous in areas close to the main water treatment plants fed directly from the transmission system, to 2 hours per day in some areas in the south.

Many residents have developed compensatory strategies to overcome the low pressures and intermittent supplies including:

- storing municipal water in buckets and informal containers;
- storing municipal water in tanks (with or without pumps);
- rescheduling activities to coincide with the availability of water;
- obtaining water from tube wells;
- obtaining water from tankers (activity operated by the GWB or private contractors).

Some of these strategies have the effect of increasing domestic water consumption as residents often leave taps open to observe when water is available, allow tanks to overflow and empty remaining water in storage when fresh supplies become available. Other negative effect is the very high peak demand for which the network is not designed. The consumers take the entire volume of water for one day within the few hours of supply.

Due to above available pressures in the network are generally low. This has encouraged residents to install in-line boosters, a practise that leads to polluted water being drawn into the network thus putting public health at risk.

The provision of intermittent water supplies is common to many cities in India. It normally leads to a spiral of decline as management of the system is extremely difficult and customer's willingness to pay declines. Specific problems of the current consumption habits include:

- serious risk to public health, resulting from ingress of contaminated groundwater into the distribution system;
- inability to practice effective supply management;
- inability to practice effective demand management;
- operational inadequacies, which unduly weaken the physical infrastructure;
- consumers' inconvenience.

One of the aims of this project is to eradicate all above negative effects of the current consumption habits through implementing a controlled operation of the water supply system. This will be achieved through providing all necessary infrastructure and tools to the future operator of the utility.

3.3.2. WATER BALANCE

In the sense of urban water supply engineering practice the water balance is comparing the proportion of the water produced with the proportion of water sold. The term of "Non-Revenue Water" (NRW) was introduced and replaces the term of UFW – "Unaccounted For Water" to express the volume of water that is not producing income for the water utility. The change was decided by IWA since the word "Unaccounted" leads to confusion between the non-measured water supplied or water not registered in the accounting department and sold.

The Water Balance is defining the volumes of water with the following structure:

<table>
<tr><td rowspan="8">System Input volume</td><td rowspan="3">Authorized consumption</td><td rowspan="2">Billed authorized consumption</td><td>Billed metered consumption</td><td rowspan="2">Revenue water</td></tr>
<tr><td>Billed unmetered</td></tr>
<tr><td rowspan="2">Unbilled authorized consumption</td><td>Unbilled metered</td><td rowspan="3">Non-revenue water</td></tr>
<tr><td>Unbilled unmetered</td></tr>
<tr><td rowspan="5">Water losses</td><td rowspan="2">Apearent losses</td><td>Unauthorized consumption</td></tr>
<tr><td>Metering inaccuracies</td></tr>
<tr><td rowspan="3">Real losses</td><td>Leakage on transmission and/or distribution mains</td></tr>
<tr><td>Leakage and overflows at storage</td></tr>
<tr><td>Leakage on service connection up to point of customer metering</td></tr>
</table>

In the case of Gaya, where the income for sold water generated through the payment of the property tax is not under the control of the operator, the entire System Input Volume equates the volume for Non-Revenue Water.

The water losses have been assumed by using experience based figures expressed in l/connection/day for systems that are developed randomly, without design, and are unmaintained. The result of the present Water Balance in Gaya is shown below:

Table 12: Water Balance for 2013 in Gaya

Description	2013
Domestic Demand [l/d]	23,164,400
Demand Floating Population [l/d]	8,400,000
Demand Hospitals [l/d]	84,000
Demand Schools [l/d]	803,000
Industrial Demand [l/]	1,870,000
Demand Livestock [l/d]	1,278,304
Conn. #	28,912
Specific Water loss value [l/conn/d]	700
Water Loss demand [l/d]	20,238,692
Total Demand [l/d]	55,838,396
Total Demand [MLD]	**55.84**
Total Demand [l/s]	**646.28**
Potential Water Production [MLD]	**68**
Water Loss [%] of production	**33%**
(+) Water Balance [MLD]	**12.16**

4. POPULATION AND DEMAND PROJECTIONS

4.1. POPULATION PROJECTIONS

The following methods were used for population projections.

1. Arithmetic method
2. Geometric increase method
3. Incremental increase method
4. Exponential graphical method
5. Linear graphical method
6. Decadal growth method

With above methods population was estimated for the year 2011 based on census populations from 1921 to 2001 and compared with the census population.

Table 13: Establishing the Population Projection Method

Sl. No	Population Projection Method	Census population	Projected Population
		Year- 2011	Year- 2011
1	Arithmetic Increase Method	468,614	433,753
2	Geometric Increase Method	468,614	478,850
3	Incremental Increase Method	468,614	441,126
4	Graphical Method (Linear Increase)	468,614	369,299
5	Graphical Method (Exponential)	468,614	463,099
6	Decadal growth increase	468,614	485,400

The Exponential Graphical Method and Geometric Increase Method are the closest to real figures. We are adopting the exponential graphical method.

The resulting population projections adopted for different horizon years are shown in Table 14 below.

Table 14: Result of Population Projections

Population Projection Method	Projected Population		
	2018	2033	2048
Exponential Graphical Method	524,297	675,237	848,200

For central wards where the population density is already high a ceiling has been defined and no further increase in population number is expected. The Ward wise population projections have been placed in the Designs Section of the present document.

4.2. DEMAND PROJECTIONS

The future demands based on the above population projections and on the data collected in the field are given below. The ward wise details of the Table 15 below are given in the Designs section of the present report.

Table 15: Demand Projections

Description	2018	2021	2033	2048
Domestic Demand [l/d]	63,675,928	71,992,214	88,185,916	112,640,928
Demand Floating Population [l/d]	8,400,000	8,400,000	8,400,000	8,400,000
Demand Hospitals [l/d]	92,400	101,640	111,804	122,984
Demand Schools [l/d]	883,300	971,630	1,068,793	1,175,672
Industrial Demand [l/]	1,870,000	1,870,000	1,870,000	1,870,000
Demand Livestock [l/d]	1,278,304	1,278,304	1,278,304	1,278,304
Conn. #	87,053	120,689	147,837	188,617
Specific NRW value [l/conn/d]	150	160	170	200
NRW demand [l/d]	13,057,904	19,310,169	25,132,282	37,723,376
Total Demand [l/d]	89,257,836	103,923,957	126,047,099	163,211,264
Total Demand [MLD]	**89.26**	**103.92**	**126.05**	**163.21**
Total Demand [l/s]	**1,033.08**	**1,202.82**	**1,458.88**	**1,889.02**
Required Water Production [MLD]	**90**	**104**	**130**	**165**
NRW [%] of production	**15%**	**19%**	**19%**	**23%**
(+) Water Balance [MLD]	**0.74**	**0.08**	**3.95**	**1.79**

In the above table the figures in the row containing the "**Water Production**" are based on the assumption that **water sources** are or **will be made available** for the respective target year. Producing (pumping) higher volumes of water will result in the increase of the NRW.

The term **"NRW"** was used in the above table to show that for all target years it is expected the Water Utility to be operated according to commercial principles.

The specific value for NRW was chosen according to statistics for a **well operated** water utility.

5. SERVICE LEVEL IMPROVEMENT PLANNING

5.1. PROPOSED IMPROVEMENTS

As per the Handbook on Service Level Benchmarking by Ministry of Urban Development GoI, following is the prescribed service level benchmarks:

S. No.	Proposed Indicator	Benchmark
1.	Coverage of water supply connections	100%
2.	Per capita supply of water	135 lpcd
3.	Extent of metering of water connections	100%
4.	Extent of non-revenue water (NRW)	20%
5.	Continuity of water supply	24 hours
6.	Quality of water supplied	100%
7.	Efficiency in addressing customer complaints	80%
8.	Cost recovery in water supply services	100%
9.	Efficiency in collection of water supply-related charges	90%

For all stages the foreseen Level of Service shall not be lower than the following targets:

Water Production: between 180 l/c/d and 194 l/c/d (for connected inhabitants)

Service coverage: not less than 99% of inhabitants

Billing: 100% of connections

NRW: less than 200 l/connection/day

Pressure: not higher than 3 bar and not less than 1.2 bar

Service interruption: not more than 3 times/month up to 3 hours each per DMA.

In the year 2018 immediately after the completion of physical works it will be difficult to achieve a rate of connection of 99%. Therefore the starting level will be considered at 95% (FP+PSP).

Table 16: Projection of the Level of Service

Year	2018	2021	2033	2048
Pop Fully Plumbed	87%	95%	96%	98%
Pop. PSP	8%	4%	2%	1%
Pop. Served [%]	95%	99%	99%	99%
Total Pipe Length [m/cap.]	1.03	1.4	1.41	1.25
Distribution Network [m/cap.]	1.0	1.39	1.4	1.2
Storage [l/cap.]	60	50	50	50
NRW [l/conn/d]	150	160	170	200

5.2. INTERVENTIONS REQUIRED FOR MEETING THE LOS

Following capital investment works are anticipated for the fulfilment of the above Levels of Service:

Table 17: Future capital investment works

Year	2018	2021	2033	2048
Tot. Water Supply Volume [MLD]	90	104	130	165
Laying of New Transmission Lines [m]	6848	2988	3586	10759
Laying of New Distribution Lines [m]	498332	244887	165050	135673
New service connections	87053	33636	114201	74416
New Storage volume to add [m^3]	21440	1500	4000	5000

6. OUTLINE FOR PHASE 2 WORKS

The population of Gaya town as per 2011 census is 468,614. Population projections and water demand projections have been made as per standard procedures prescribed in CPHEEO Manual of Water Supply and are placed in Design section of this report. The projected populations and water demand for key years are given in the Table 18 below:

Table 18: Steps of Implementation

No.	Year	Event	Population	Demand (MLD)
1	2018	Completion of Phase I works	524,297	89.26
2	2021	Target year of Loan Agreement	552,723	103.92
3	2033	Mid design year	675,237	126.05
4	2048	Design Year	848,200	163.21

The present supply of water to the town from various sources has been determined at 27.62 MLD as per Table 3 showing much under utilisation of potential of installed facilities due to improper planning, power interruptions and frequent need for repairs.

The feasibility of carrying out rehabilitation of existing sources and pumping system has been done to utilise the existing sources to their optimum level. It is estimated that by carrying out this exercise and undertaking related works it will be possible to increase the production from existing sources to a level of 68 MLD.

The works of Phase I of this project is expected to be completed by 2018. Thus it is evident that there will be a shortfall of nearly 22 MLD of water in 2018.

Based on the recommendations of Hydro-geological study mentioned in the sub-section 2.2 above, following options are possible:

i. There is adequate ground water available in the aquifer to meet the designed demand of 163 MLD in 2048 on sustained basis. In such a case, balance demand of water can be met by construction of additional Tube Wells, related pumping system and transmission system.

ii. The availability of ground water is limited but can be increased by construction of a barrier across river Phalgu such that demand for 2048 is met on sustained basis. In this case also, action as per (i) above can be taken together with construction of required structure across river Phalgu.

iii. The availability of ground water can be increased by constructing the barrier across the river but even improved availability will be able to partially meet the projected demand. In such a case we can determine as to for which year water demand can be met with this improved water availability. For the remaining demand for the design year 2048, we shall be required to look for alternative ground water or surface water source.

iv. The availability of ground water may found to be limited and may not be adequate to meet the demand beyond 2018 and in that case we may have to go for a surface source only. One of the potential surface water source considered in the past is river Ganga near Fatuah village, nearly 100 km from Gaya. However, looking at the complexity and volume and cost of work involved it is likely to take substantial time for planning and execution of works.

As mentioned earlier in this report, proposals under Phase I of the project included in this DPR will consider Redevelopment of existing TWs and repair/new pump rooms on them, Rehabilitation/Replacement of existing electro-mechanical equipment on Tube Wells, construction of additional Service Reservoirs to meet the projected requirement of 2048, rehabilitation of the existing distribution pipe lines to ensure reduction in NRW level to 20% and extension of the distribution network to all uncovered areas to achieve coverage of 95% population by 2021,

formation of adequate number of DMAs to facilitate monitor and help achieve NRW below norms prescribed under loan agreement, rehabilitation of service connections, release of new connections and providing water meters to all existing and future consumers.

The scope of work in Gaya Water Supply Phase II will be to develop new source(s) of water and related treatment and transmission system up to all existing and new Service Reservoirs to meet the projected demand of water for design year 2048. Work of service reservoirs deferred during Phase I are proposed to be included in Phase II. A SCADA system is also proposed to be provided in Phase II for the system going to be developed in Phase II as well as the system developed in Phase I so that the total system is operated and maintained optimally and efficiently.

In case an Urban Development Plan will be available by the beginning of the design for Phase II where future streets will be shown, the distribution network for future extensions will be designed.

7. PROPOSED REHABILITATION OF TUBE WELLS & ELECTRO-MECHANICAL EQUIPMENT

7.1. REDEVELOPMENT OF TUBE WELLS

The 29 tube wells being operated by GMC are old ranging from 6 to 50 years range. These tube wells have not been developed or flushed after their commissioning even once as per information obtained from local staff. This shows that the tube wells are presently not working with full efficiency and with full capacity. Non-development of tube wells regularly results in sand pumping, incrustation and clogging of slots of well screen. It is recommended that tube wells are redeveloped every five years. It is therefore proposed to redevelop all the 29 tube wells by first putting chemicals like Sodium hexa metaphosphate and then with compressed air so that all loose sand particles and clogging in the screen slots and incrustation in filter media are removed. As depth of tube wells is quite less, development for a period of 10 hours on an average looks to be adequate. It is further proposed to undertake pump test of each TW with a higher capacity pump to determine the actual yield to facilitate installation of right capacity pump and make use of TW optimally.

7.2. TUBE WELL WATER PUMPING

There are 31 tube wells of GMC. The condition of Tube Wells of GMC is not very good as they are quite old (ranging from 6 years to 50 years). It would be appropriate to undertake redevelopment of these tube wells. This is likely to improve the discharge and efficiency of tube wells and also make their discharge sand free.

There are 8 tube wells constructed by PHED under 12th Finance Commission project for GMC between 2009 and 2011, of which 2 are proposed to work as stand by TWs. These are new tube wells and are in the process of commissioning. Two Tube Wells have so far been commissioned. These TWs have not been handed over to GMC so far but production from the operating TWs is used for water distribution.

The pumping machinery installed on GMC tube wells is generally old and undergoes frequent breakdowns. There are no flow meters, pressure gauges, depth gauges and Non Return Valves installed in delivery pipe lines. As will be evident from Table 3, many of the TWs are operated for much less period than availability of power on account of such TWs being connected directly to distribution system. It would be appropriate to connect all TWs to some service reservoir so that they are optimally utilised.

It has also been noticed that yield of TWs is not optimally used on account of lower capacity of pumps installed or discharge of pumping sets having got reduced due to passage of time or frequent repairs. One such example is TWs at Dandibagh well field. Whereas all the five TWs are constructed in the same aquifer within small area and are of same size, are giving different production. It is therefore proposed to rationalise the proposed pumping rate form the TWs to make optimum use of TW capacities.

One of the important issues is average quantum of water supplied daily, which is much less than the quantity of water produced daily worked out in Table 3. This is on account of various factors like frequent breakdown of electro-mechanical system due poor condition of electrical system, no protections provided in electrical system, absence of valves in pump delivery system, non availability of pressure gauges and level sensors making it difficult to determine/monitor performance level of TW etc.

It is therefore proposed to replace pumping sets on existing 29 out of total 31 tube wells of GMC (One TW is proposed to be left for use for fire fighting and one has become defunct) with following duty conditions:

Table 19: Proposed duty condition for TW refurbishment

ID	Name	Discharge	Head	Motor	Operating	Daily Production	Remarks
		m^3/h	m	HP	Hours	MLD	
1	Dandibagh No. 1	220	85	105	23	5.06	
2	Dandibagh No. 2	220	85	105	23	5.06	
3	Dandibagh No. 3	220	85	105	23	5.06	
4	Dandibagh No. 4	220	85	105	23	5.06	
5	Dandibagh No. 5	220	85	105	23	5.06	
6	Panchayati Akhara No. 1	100	65	40	20	2.00	
7	Panchayati Akhara No. 2	100	65	40	20	2.00	
8	Azad Park	55	49	25	20	1.10	
9	Dhobighat	40	69	20	20	0.80	
10	Central School	75	71	35	20	1.50	
11	Nigam Store	20	71	10	20	0.40	
12	Gurudwara	55	71	25	20	1.10	
13	Fire Station	-	-	-			Used for Fire fighting
14	New Godown	55	71	25	20	1.10	
15	Kharkhus	40	53	15	20	0.80	
16	Delha	40	53	15	20	0.80	
17	Panchayati Akhara No. 3	100	65	40	20	2.00	
18	Janata Colony 1	40	71	20	20	0.80	
19	Janata Colony 2	20	71	10	20	0.40	
20	Pilgrim Hospital	20	49	7.5	20	0.40	
21	Visnupad	130	95	70	20	2.60	
22	Bypass	75	95	45	20	1.50	
23	Bairagi Powerganj	55	71	25	20	1.10	
24	Bageshwari Pachim	20	69	10	20	0.40	
25	Pitamaheshwar	75	71	35	20	1.50	
26	Kauvasthan	20	49	7.5	20	0.40	
27	Hata Godown	55	71	25	20	1.10	
28	Manpur	100	69	40	20	2.00	
29	Manpur - Buniydiganj	75	43	20	20	1.50	
30	Khadigramodyog Lakhibagh	55	47	15	20	1.10	
31	Cotton Mill	-	-	-	-	-	Non-functional
32	Krilosker-1	150	129.1	85	0	0	No Replacement proposed
33	Krilosker-2	170	129.1	100	20	3.4	- Do -
34	Krilosker-3	75	129.1	35	20	1.5	- Do -
35	Krilosker-4	170	129.1	100	23	3.91	- Do -
36	Krilosker-5	170	129.1	100	23	3.91	- Do -
37	Krilosker-6	170	129.1	100	0	0	- Do -
38	Kirlosker-7	170	129.1	100	0	0	- Do -
39	Krilosker-8	75	76	35	20	1.5	- Do -