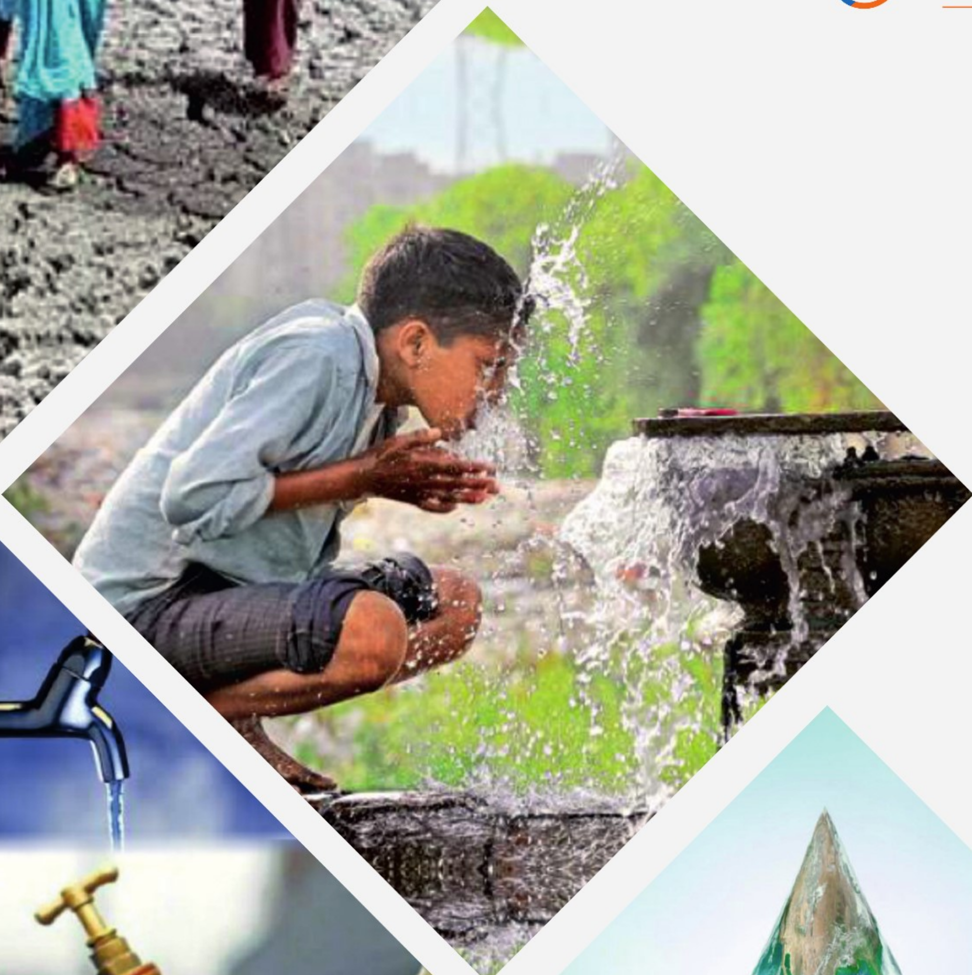
NON REVENUE WATER (NRW) ASSESSMENT & REDUCTION STRATEGY FOR LUCKNOW

Detailed Project Report

Ceinsys Tech Ltd
Formerly ADCC Infocad Ltd



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ABBREVIATIONS

AC	**Asbestos Cement**
ALC	Active Leakage Control
ALR	Awareness, Location and Repair
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
ARV	Annual Rental Value
AZP	Average zonal pressure
Acronym	Expansion
CDP	City Development Plan
CGRS	Consumer Grievance Redressal System
CI	Cast Iron
CPHEEO	Central Public Health and Environmental Engineering Organisation
CPP	Critical pressure point
DEM	Digital Elevation Model
DM	District meter
DMA	District Metered Area
EPC	Engineering, Procurement and Construction
ESR	Elevated Service Reservoir
FEED	Front End Engineering and Design
GIS	Geographic Information System
GOI	Government of India
GPR	Ground Penetrating Radar
GPS	Global Positioning System
GSM	Global System for Mobile
GSR	Ground Service Reservoir
ICT	Information and Communication Technology
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
JUSCO	Jamshedpur Utilities and Services Company limited
LMC	Lucknow Municipal Corporation
MCGM	Municipal Corporation of Greater Mumbai

MDB	Multilateral Development Bank
MFI	Multilateral Financial Institution
MLD	Million Litres per Day
MoUD	Ministry of Urban Development
MS	Mild Steel
NA	Not Available
NABL	National accreditation board for testing and calibration laboratories
NRW	Non-Revenue Water
OHT	Over Head Tank
POS	Point of Sale
PPP	Public Private Partnership
PS	Pumping Station
PSC	Pre-Stressed Concrete
PVC	Poly Vinyl Chloride
RCC	Reinforced Cement Concrete
ROA	Return on Assets
RW	Raw Water
SCADA	Supervisory Control and Data Acquisition
SLB	Service Level Benchmark
SLIP	Service Level Improvement Plan
SWB	Smart Water Billing
SWMS	Smart Water Management System
ULB	Urban Local Body
USFM	Ultra-Sonic Flow Meters
WTP	Water Treatment Plant
WW	Water Works
ZPS	Zonal Pumping Stations

1 BACKGROUND

1.1 OBJECTIVE

The Government of India has launched the Smart City Mission on 25th June 2015.The objective is to promote sustainable and inclusive cities that provides core infrastructure and give a decent quality of life its citizen a clean and sustainable environment and application of smart solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model, which will act like a lighthouse to other aspiring cities. The Smart City Mission is meant to set examples that can be replicated both within and outside the Smart city, catalysing the creation of similar Smart cities in various region and parts of the country. Some of the core infrastructure element in a Smart city would include adequate water supply. Lucknow city is one of the selected city in Smart City Mission, in this report NRW assessment and reduction strategy of Lucknow municipal corporation water supply system explained.

It includes

- Details of options for implementations of NRW strategy along with outcomes.
- Road map for rationalization of user charges
- Details of improvement required to achieve the objectives
- Preparation of details for funding options for implementation

With this project, MoUD aspires to enable provision of continuous pressurized water supply services to the customers. It plans to provide seamless convergence with "AMRUT" for implementation of NRW Reduction Strategies.

1.2 SCOPE

To achieve the assigned objective of NRW assessment by Smart City Mission the following assessment activities such as AS-Is situation of water supply system, water balance as per IWA, present level of NRW losses, NRW reduction strategy, Funding option has been assessed, to enable continuous pressurized water supply to the consumers.

1.3 ABOUT DELIVERABLES

1. Inception Report
   This report consists of approach and methodology of NRW assessment work, and detailed work break down structure and manpower proposed in align with the ground reality of the Lucknow Municipal Corporation.
2. 1st Interim Report
   The report consists the detailed results of the collection and analysis of existing data, assessment of existing situation, sample survey conducted detail, development of a strategy for structural control and reduction of NRW in phased manner. Preparation of the proposed reduction losses. Bulk water audit up to WTP outlet.
3. 2nd Interim Report
   The report consists the detailed results of the detail of area wise water loses (in each DMA or supply zone), detail of identified reasons for water losses, detail of physical and commercial losses. Physical and commercial reduction forecast. It contains distribution losses, transmission losses, DMA losses, litres per capita demand of water, and its water balance.
4. 3rd Interim Report

The report consists the detailed results of the details of options for implementations of NRW strategy along with outcomes and details of improvement required to achieve the objectives, preparation of details for funding options for implementation.

5. Draft Detailed Project Report

   The report consists of all necessary technical information in comprehensive and coherent appendices. It shall include summary of methodologies used, assumptions made, input data and results of such studies. Further the report will summarize results of an IWA standard water balance; based on the usual data collection and verification (The strategy for reduction of NRW shall include description of the NRW assessment activities & their results, water balance and performance indicators, institutional and human resource capacity issues. Non-Revenue Water Management, analysis of alternatives and options for physical and commercial loss reduction; a phased NRW reduction activity plan including physical and commercial loss reduction forecasts; Roadmap for improvement in current system. Funding options proposed and finalized for implementation. Financial option, budgetary cost estimation of NRW reduction project and its action plan.

6. Detailed Project Report

   This report is an umbrella report with comprehensive summaries of previously submitted reports and appendices

1.4 STRUCTURE OF REPORT

The structure of the report is guided by the need for convenience of compiled the core engineering proposals in one volume and providing the details in separate volumes.

The report is divided in to four volumes as below-

1. Part 1- Detailed Project Report
2. Part 2- Cost estimates & General Assumptions, Project Implementation & Funding option.
3. Part 3- Annexures
4. Part 4-Drawings

PART-1

PROJECT DETAILS

2 PROJECT BACKGROUND AND RATIONALE FOR THE PROJECT

2.1 DESCRIPTION OF THE PROJECT AREA

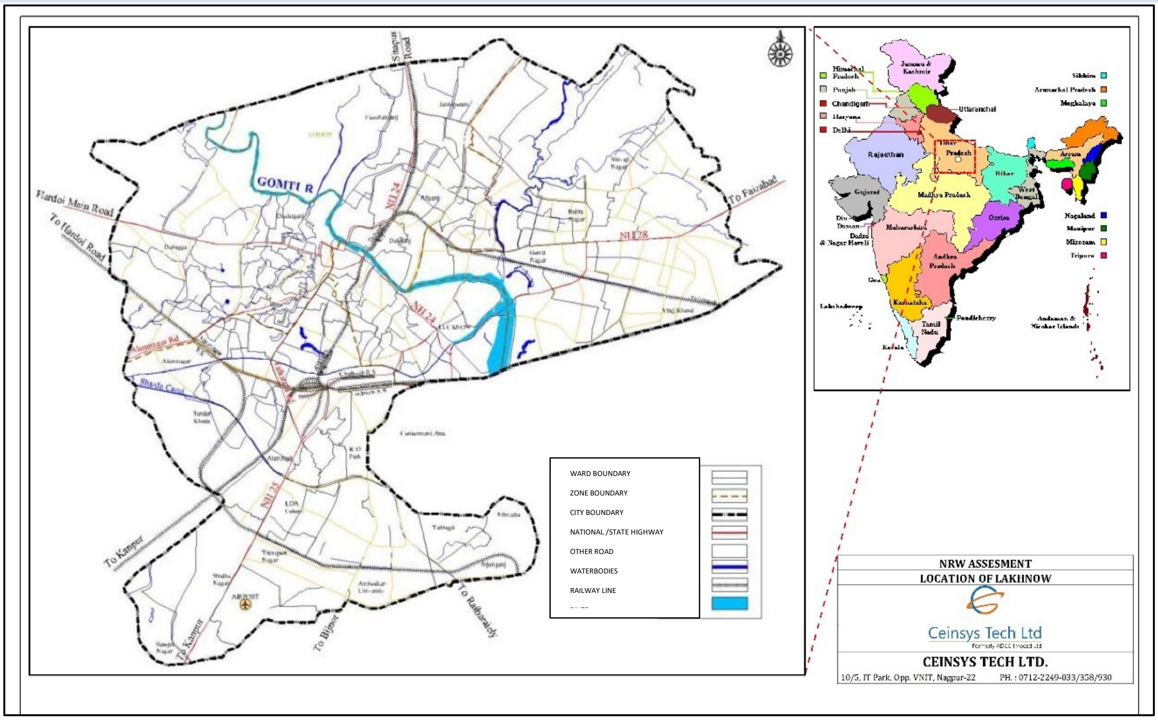


Figure 1: Lucknow City Map

The Detailed Project Report has been prepared for the area of Lucknow Municipal Corporation. Lucknow, the capital of the state of Uttar Pradesh is the largest and the most developed city in North India after Delhi. It has been listed the 17^{th} fastest growing city in India and 74^{th} in world. It is the administrative headquarters of Lucknow district and Lucknow division. Lucknow has always been known as a multicultural city and flourished as a cultural and artistic capital of North India. Lucknow city contributes 6.33% of urban population in total of state's urban population. The city is famous for its heritage character and popularly known as a seat of Nawabs. The city is now among the fastest growing cities of India and is rapidly emerging as commercial and retailing hub. Being the capital city, it is a seat of government and the trading hub for nearby towns, Lucknow is also referred to as **"Golden City of the East".**

The capital of Awadh was earlier controlled by the Delhi Sultanate and it later came under Mughal rule. It was later transferred to the Nawabs of Awadh. In 1856, the British East India Company abolished local rule and took complete control of the city along with the rest of the State; in 1857, transferring it to the British Empire.

2.1.1 Geography

Lucknow is situated in the upper Gangetic plains of India. The Gomti River is Lucknow's chief geographical feature and it divides the city into the Trans-Gomti and Cis-Gomti regions. The city is situated in the middle of the Indus-Gangetic Plain and is surrounded by rural towns and villages: the orchard town of Malihabad, Kakori, Mohanlal ganj, Gosainganj, Chinhat, and Itaunja. It is bounded on the east by Barabanki, on the west by Unnao, on the south by Raebareli and in the north by Sitapur and Hardoi. Lucknow city is in seismic zone III.

The city is situated at an elevation of approx. 123 mtr. above sea level. Lucknow district covers total area of 2,528 sq. km. It receives rainfall of around 44 cm from July to September month.

2.1.2 Climate

Lucknow has a humid subtropical climate with cool, dry winters from mid-November to February and dry, hot summers from late March to June. The rainy season is from July to mid-September, when the city gets an average rainfall of 89.62 cm from the south-west monsoon winds, and occasionally frontal rainfall will occur in January. In winter, the maximum temperature is around 25 °C and the minimum is in the 3 °C to 7 °C range. Fog is quite common from mid-December to late January. Occasionally, Lucknow experiences colder winter spells than places like Shimla and Mussoorie which are situated way high up in the Himalayas. In the extraordinary winter cold spell of 2012–13, Lucknow recorded temperatures below freezing point on 2 consecutive days and the minimum temperature hovered around freezing point for over a week. Summers are very hot with temperatures rising into the 40 °C to 45 °C range, the average highs being around 30s (°C). Generally, the summers in Lucknow record temperature within the range of 29°C to 45°C while the winters record temperature between 11.1 °C to 21.1 °C.

2.1.3 Accessibility

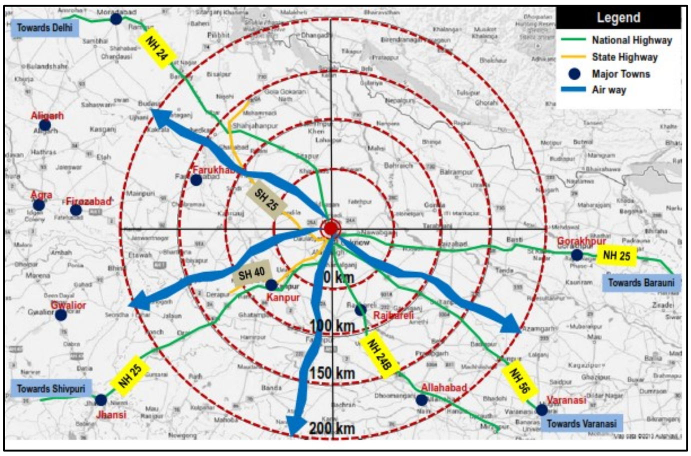
2.1.3.1 Roadways

There are four national highways and four state highways in the city:

Table 1: National & State Highways

National Highways	State Highways
NH 24 connects Delhi	SH 25 connects Hardoi
NH 25 connects Bhopal via Jhansi	SH 36 connects Rae Bareli
NH 28 connects Makama (Bihar)	SH 56 connects Sultanpur
NH 56 connects Varanasi	SH 40 connects Mohaan

Numerous bridges across Gomti river have been constructed to offer improved connectivity. Hardinge Bridge (near Imambara), Iron Bridge (at Daliganj), University Bridge and Nishathganj Bridge are old bridges providing connectivity primarily in the older part of the city. Gomti Barrage, Gandhi Setu and Ambedkar Park bridge are a set of parallel bridges providing good connectivity in the new part of Lucknow.



Source: City Development Plan Lucknow City-2040 Volume- I

Figure 2: Lucknow Linkages and Connectivity

2.1.3.2 Railways

Lucknow provides rail connectivity to major towns across India. Lucknow has two major railway stations, first Charbagh main station (broad gauge) providing connectivity to Delhi, Kolkata, Bhopal, Jaisalmer and Charbagh Junction (meter gauge) for Kanpur, Mumbai, Pune, Bangalore, Ernakulam etc. Apart from these two major stations, there are fourteen sub stations in the city area and in the surroundings.

2.1.3.3 Airways

Chaudhary Charan Singh International Airport is located 11 km from the centre of the city provides air connectivity to major urban centres in India name a few Ahmedabad, Bangalore, Chennai, Bhubneswar, Bhopal, Delhi, Indore, Hyderabad, Kolkata, Mumbai, Patna etc. It has both domestic as well international terminals. A daily domestic flights Lucknow airport provides direct flights to Dubai, Jeddah, Muscat and Riyad.

2.1.4 Public Transport

The Lucknow Metro is an under construction rapid transit system in the city of Lucknow. The construction for the Phase-I A covering total length of 22.878 km from CCS Airport to Munshi Pulia began on 27th September 2014 with a completion date of March 2018. It would be built and operated by Lucknow Metro Rail Corporation (LMRC). As per the proposed plan, the Phase-I of Lucknow Metro will constitute three corridors.

The proposed three corridors are:

a) **North-South Corridor**
This will connect Munshipulia in the north to Amausi airport in the south. This corridor is expected to have 21 stations.

b) **Gomtinagar Link**
Trains coming from the Airport Terminal will be diverted towards Gomti Nagar at the Indira Nagar Trisection (Polytechnic Crossing).

c) **East-West Corridor**
This will connect Lucknow railway station at Charbagh in the east to Vasantkunj on Hardoi Road in the west. This corridor is expected to have 12 stations.

2.1.5 Urban Slums

There are around 787 slums in Lucknow. Slum population is increasing at a fast pace of 8% of the population and 26% in 2011. The total area under slum is 11 sq. km. (3%). Almost 50% of the slums are located around key drain areas and waterbodies.

The total population residing in slums is 7,74,546 and number of households is 1,29,091. Almost 30% of the houses in slum are in good condition pucca houses which cannot be considered as slum. However, only 27% of the households in slums are connected to the network.

2.1.6 Sewage

The city has a total of 37 nullahs along the length of the intercepting drain but only 22 are tapped so far and diverted to the older Bharwara STP for treatment. The new STP will help in tapping remaining drains.

Jal Nigam has been allotted a grant of Rs. 302 crores to fix the infrastructure that conveys sewage and surface run-off. It has been planned under the sewerage district IV scheme of JNNURM. In the first phase, Rs. 187 crores will be spent to lay sewer lines and connect them to the main line. In the second phase, the remaining fund will be used to set up a sewage pumping station.

2.1.7 Storm Water Management

LMC has recently come up with storm water drainage management project for the areas like South City, Ashiana, Alambagh, LDA Colony Kanpur Road and Transport Nagar that often face the problem of water logging. These areas are the most flood prone spots in the city.

Currently, LMC has only one Qila Mohammadi drain to fall back upon. This drain is also blocked at several places as the level of drain is lower than that of culverts near Bijnore.

2.1.8 Civic Administration

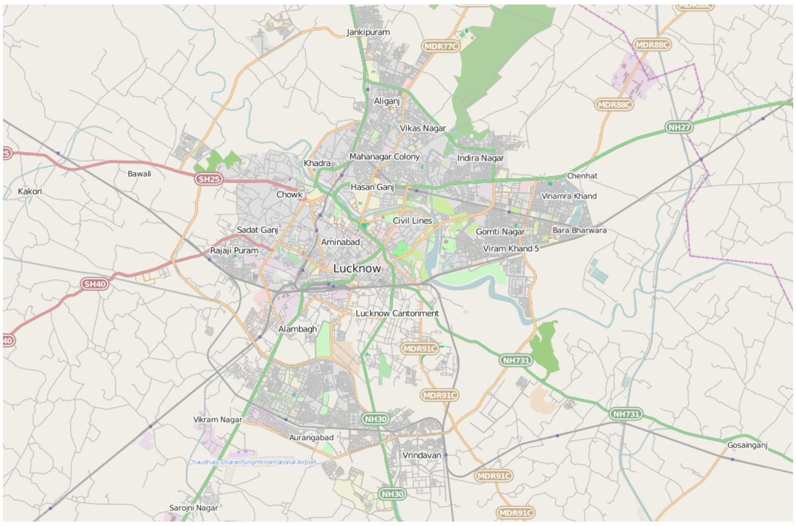


Figure 3: Zonal Map of LMC

Source: City Development Plan Lucknow City-2040 Volume- I

Lucknow was administered as Municipal Committee till the year 1884, later, in the same year, it was upgraded to Municipal Board and continued working so till 1995. Lucknow Nagar Mahapalika was constituted in the year 1959 under Uttar Pradesh Nagar Mahapalika Act 1959. At the time of constitution, total area under its jurisdiction was 48 sq. km. which was expanded gradually to 101 sq. km., 107 sq. km., 118 sq. km. and 350 sq. km. till the year 1987. Under 74th constitution amendment act, Lucknow Nagar Mahapalika was again reconstituted in May 1994 and given the status of Municipal Corporation.

Table 2: Zonal and Ward details of LMC

Zone 1	**13,17,23, 29, 34, 46, 48, 57, 65, 72, 76, 79, 93, 94, 95, 100**
Zone 2	3, 5, 7, 14, 33, 39, 50, 54, 55, 60, 64, 68, 71, 83, 96, 98, 106, 110
Zone 3	12, 27, 32, 35, 43, 51, 56, 61, 62, 63, 67, 74, 77, 82, 89, 91, 102, 103
Zone 4	11, 32, 36, 40, 42, 45, 52, 81
Zone 5	4, 15, 18, 19, 20, 22, 26, 28, 44, 69, 75
Zone 6	9, 16, 25, 47, 53, 59, 70, 78, 80, 85, 86, 90, 92, 97, 101, 104, 105, 107, 108, 109
Zone 7	6, 8, 24, 30, 37, 38, 41, 49, 58, 84, 87, 99
Zone 8	1, 2, 10, 21, 66, 73, 88

Source: Lucknow Municipal Corporation

2.1.9 City Statistics

Table 3: LMC Statistics as of 2011

Lucknow City	Total	Male	Female
City Population	28,17,105	14,60,970	13,56,135
Literates	20,81,727	11,24,261	9,57,466
Children (0-6)	2,93,697	1,54,226	1,39,471
Average Literacy (%)	82.50%	86.04%	78.70%
Sex Ratio	928		
Child Sex Ratio	904		

Source: Lucknow Municipal Corporation

2.1.10 Socio Economic Condition

The objective of the Revised City Development plan is to focus on the development of economic and social infrastructure, policies and programs addressing the specific issues of the urban poor, strengthens of municipal governments, and their financial management and accounting process, promoting transparency in their functioning etc. [1]

2.2 POPULATION COVERAGE AND ACCESS TO WATER SERVICES

As per Census 2011, total population of Lucknow is 28.17 lakhs with total area of 350 sq. km. and density of 8049 persons / sq. km. Lucknow city is divided into eight zones which is further subdivided into 110 wards.

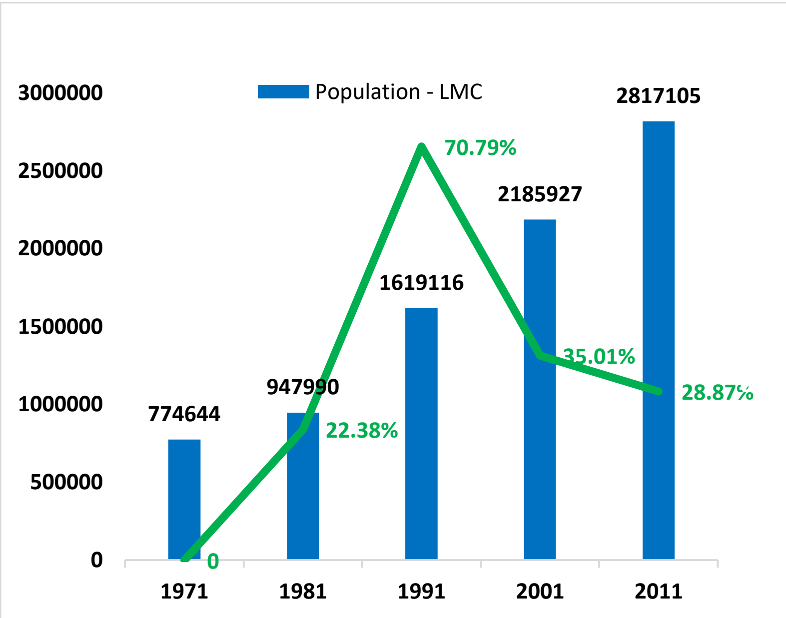


Figure 4: Census data on LMC population

[1] Revised City Development Plan Lucknow City-2040 Volume- I

Hindi is the primary language of the city with Urdu being widely spoken as well. Lucknow is the centre of Shia Islam in India with the highest Shia Muslim population in India.

2.2.1 Population projection

The projection of population for next Census year – 2021 is done using 4 different methods as below. Detailed information is added to Annexures.

Table 4: Population projection for the Year 2021

All figures are in numbers				
Methods	**Arithmetic Increase**	**Geometric Progression**	**Incremental Increase**	**Average population**
2021	3440143	3986682	3481375	3636066

Source: Lucknow Municipal Corporation

2.2.2 Projections on water demand

As per the global standards, for household, water consumption is around 133 LPCD. Thus, on the basis of population projections, appropriate water demand can be projected. Further, the estimated water demand for a city can be broadly classified as domestic and non-domestic water supply. The domestic water demand includes per capita consumption and system losses, while non-domestic water demand includes industrial, commercial and institutional consumption along with usage for firefighting situations.

2.2.3 Population Projection Method wise

Table 5: Population projection Method Wise

All figures are in numbers						
Year	**Census Population**	**Arithmetic Increase**	**Geometric Progression**	**Incremental Increase**	**Average**	**Population Growth Rate**
1951	4,59,484					
1961	6,15,523					33.96%
1971	7,74,644					25.85%
1981	9,47,990					22.38%
1991	16,19,116					70.79%
2001	21,85,927					35.01%
2011	28,17,105					28.87%
2021		34,40,143	39,86,682	34,81,375	36,36,066	29.07%
2031		40,63,182	56,41,831	4064,456	45,89,826	26.23%
2041		46,86,220	79,84,148	46,27,581	57,65,983	25.63%

Source: City Development Plan Lucknow City-2040 Volume- I

2.2.4 Population Density Scenario

Year	Population Total – LMC	Area in Sq. Km	Density (persons/Sq.km)
1951	4,59,484	48	9573
1961	6,15,523	107	5753
1971	7,74,644	101	7670
1981	9,47,990	118	8034
1991	16,19,116	350	4626
2001	21,85,927	350	6246
2011	28,17,105	350	8049

Source: City Development Plan Lucknow City-2040 Volume- I

2.3 LUCKNOW WATER UTILITY

2.3.1 Institutional Structure

Jal Nigam and Jal Kal Sansthan are 2 organizations responsible for water related management and development activities in Lucknow under the aegis of Lucknow Municipal Corporation.

2.3.2 Jal Nigam

The State government constituted a corporation by the name of UTTAR PRADESH JAL NIGAM in the year 1975 which came into existence with effect from June 1975. Its area of operation extends to whole of Uttar Pradesh excluding Cantonment areas under an Act called as Uttar Pradesh Water Supply & Sewerage Act, 1975. The basic objective of creating this corporation is development and regulation of water supply & sewerage services and for matters connected therewith.

It works as a purely EPC body. Jal Nigam is involved in setting up of WTPs working on BOT model.

2.3.3 Jal Kal

Under the 74th Constitutional Amendment Act of the Government of India, three levels of local bodies were set up to ensure public participation in power, whose purpose is to provide pure water supply and sewer arrangements to the citizens. To fulfil this objective, the Lucknow Jal Sansthan was set up under Section 18 (1) of the Water Supply and Sewerage Act, 1975 by the UP Government.

<u>Mission / Vision of Lucknow Jal Sans than:</u>
Provide citizens with adequate quantity of water, proper pressure and proper water supply at the proper place. Also, provide better sewer facility to the citizens.

<u>Roles</u>

- To make plans for water harvesting, to promote and execute them, and to maintain efficient systems of water conservation
- To plan for sewer arrangement, sewage treatment and salvage and purification of business fluids, its promotion and execution and its enforcement cleaning of manholes and maintaining sewer lines wherever possible
- To manage their activities in such a way that people of the area coming under their jurisdiction can get healthy water and, wherever possible and appropriate, arrangement of sewer arrangements can be done
- To take other measures that are necessary to ensure water supply in the state of emergency situations
- To maintain hand pumps installed in the city, install and maintain stand posts
- To provide new water / sewer connections
- To impose and recover water tax, sewer tax and water tariff

<u>Responsibilities</u>

- Ensure uninterrupted pure drinking water in the city
- Provide citizens with sewer facility
- Create awareness among citizens about the protection of water
- Prevent infection in Water Supply

- Ensure transparency in the work of water institutions and better facilities to the citizens

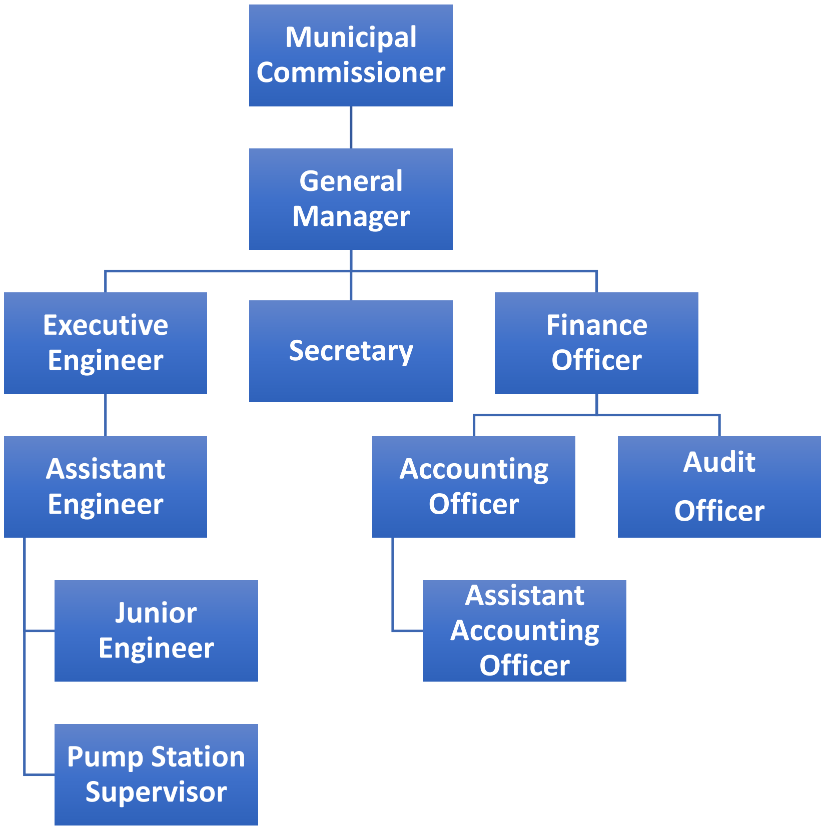


Figure 5: Jal Kal Organization Structure

2.4 NON-REVENUE WATER (NRW) AT A GLANCE

2.4.1 Introduction

NRW is water that has been produced but does not result in revenues for the utility. NRW may be due to "real losses" (as a result of leaks and wastage, sometimes called as "physical losses") and "apparent losses" (as a result of metering inaccuracies, theft, meter taping, etc. sometimes called as "commercial losses"). High levels of NRW are detrimental to the financial viability of the utility as well as to the quality of water. NRW is thus calculated as volume of water lost.

$$\text{NRW (\%)} = \frac{\{System\ Input\ Volume\ (m\text{^}3) - Billed\ Consumption (m\text{^}3)\}}{System\ Input\ Volume\ (m\text{^}3)}\ x\ 100\%$$

The total quantity of water in the world is roughly 1357.5[2] million cubic kilometers (Mkm^3). About 97% of this water is contained in the oceans as saline water and only 37.5 Mkm^3 is fresh water. Out of this about 8.5 Mkm^3 is both liquid and fresh and the remaining is contained in frozen state as ice in the Polar Regions and on mountains tops and glaciers. Water demand is increasing day by day due to increase in population, urbanization, agriculture, industrialization etc. The groundwater table is falling rapidly throughout the world due to wide spread over pumping using powerful pumps. More than 2.6 Billion people – over 40% of the world's population do not have access to safe drinking water. Water Scarcity in India is widespread in all states.

[2] IOSR Report on NRW, 2013

2.4.2 NRW levels in the World

The World Bank has estimated the total cost of NRW to utilities worldwide at US$14 billion per year. Reducing by half the current levels of losses in developing countries, where relative losses are highest, could generate an estimated US$ 2.9 billion in cash and serve an additional 90 million people. Most available data on NRW levels are expressed in percentage terms, ranging from 7% in Germany to more than 90% in Lagos, Nigeria. NRW levels are 10% in Denmark, 19% in England and Wales, 26% in France, 29% in Italy. In Asian large city NRW varies from 10% to 60%. According to a report by the European Environment Agency NRW in Yerevan, Armenia, was almost 80%.

2.4.3 NRW levels in India

In developing countries, roughly 45[3] million cubic meters of water are lost daily with an economic value of over US$3 billion per year.

A World Bank study puts the global estimate of physical water losses at 32 billion cubic meters each year, half of which occurs in developing countries. Water utilities suffer from the huge financial costs of treating and pumping water only to see it leak back into the ground, and the lost revenues from water that could have otherwise been sold. If the water losses in developing countries could be halved, the saved water would be enough to supply around 90 million people.

From the study[4] conducted in India, components of NRW are 1.5 to 3.5% public use, 3.5 to 6.5% illegal / unmetered connection, 10 to 15% meter under registration and 75 to 85% is leakages.

[3] http://blogs.worldbank.org/water/what-non-revenue-water-how-can-we-reduce-it-better-water-service, 2016

[4] http://blogs.worldbank.org/water/what-non-revenue-water-how-can-we-reduce-it-better-water-service, 2016

2.5 NRW LOSSES

Source: Tata and Howard Unsurpassed Solution in Water Environment

NRW related inefficiencies are displayed in below diagram. It is called Vicious NRW Cycle. Desired state is Virtuous Cycle; this requires transformation as described below.

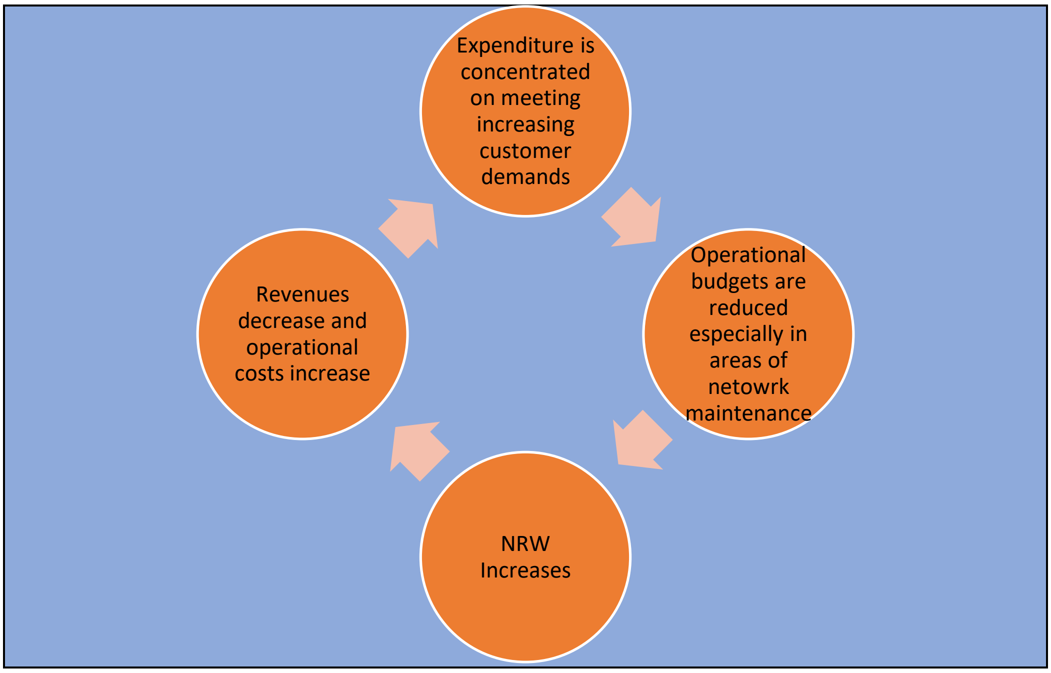


Figure 6: The Vicious NRW Cycle

The challenge for water utility managers is to transform the Vicious Circle into the 'Virtuous Circle'. In effect, reducing NRW releases new sources of both water and finances. Reducing excessive physical losses results in a greater amount of water available for consumption and postpones the need for investing in new sources. It also lowers operating costs. Similarly, reducing commercial losses generates more revenues.

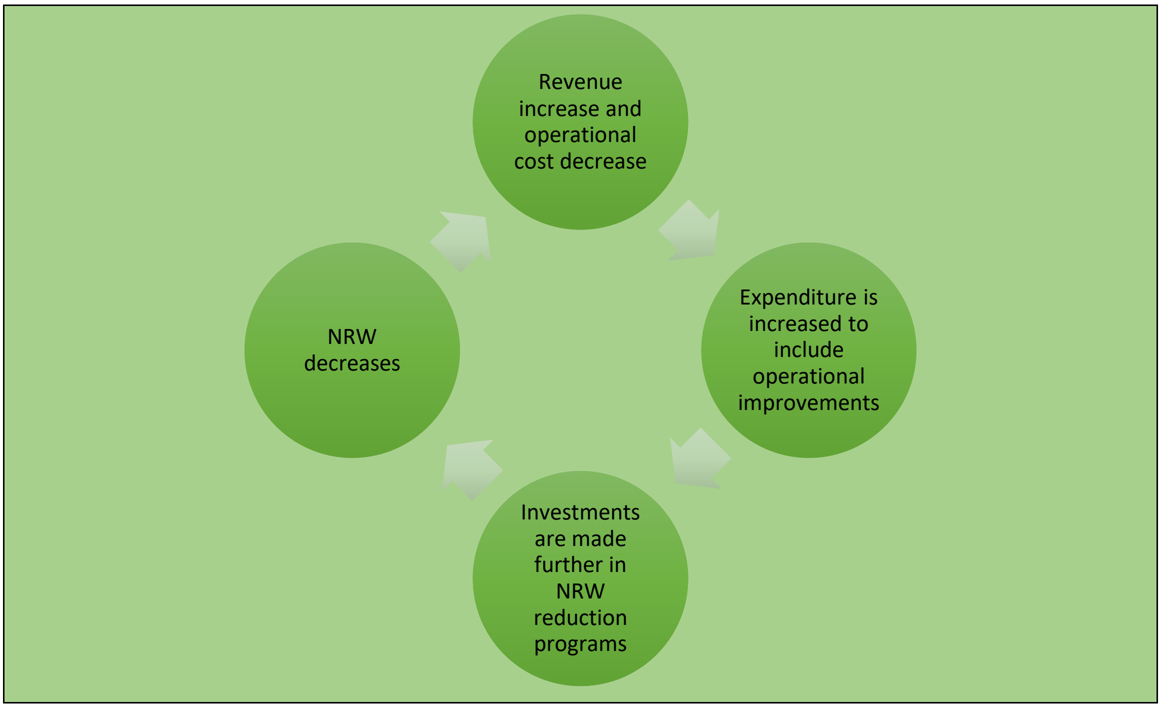


Figure 7: The Virtuous NRW Cycle

Poor governance also affects NRW reduction. Utility managers often lack the autonomy, accountability, and technical and managerial skills necessary to provide reliable service. The utility's management should also tackle organisational challenges, such as policy barriers, inadequate technical capacity, and aging infrastructure. Finally, poor project design hinders efforts to reduce NRW, particularly underestimating the required budget.

As per of next few reports, we will cover detailed analysis in below format.

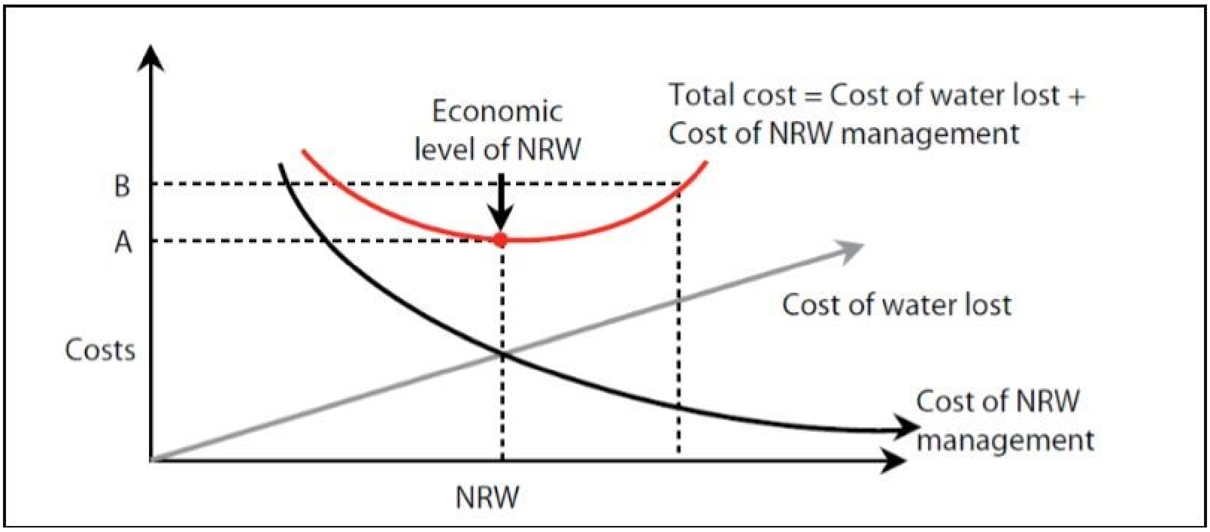


Figure 8: Economic Level of NRW

The cost of water lost is the value of the water lost through both physical and commercial losses. The volume of physical losses should be multiplied by variable operational costs, including manpower, chemicals, and electricity. The volume of commercial losses should be multiplied by the average customer tariff. As NRW increases, the cost of water lost increases proportionally.

The cost of NRW management is the cost of reducing NRW, including staff costs, equipment, transportation, and other factors. As NRW decreases, the cost of NRW management increases.

Table 6: Volume and Cost Analysis for NRW Management activities

NRW Type: U=Unbilled authorised consumption, C=Commercial Losses, P=Physical losses

		Cost		
		High	Medium	Low
Volume	High	Leakage on Mains (P) Leakage on service connections (P)	Unauthorised Consumption (C)	Unbilled unmetered consumption (U)
	Medium	Customer meter replacement (C)	Customer metering inaccuracies and data handling errors (C)	Pressure Management (P)
	Low	Reservoir leakage (P)	Unbilled unmetered consumption (U)	Reservoir overflows (P)[5]

[5] Managers: Non-revenue water handbook

2.6 BENEFITS OF NRW REDUCTION

Reducing water loss directly improves water utilities' bottom line, in addition to offering social and environmental benefits.

2.6.1 Increased Revenue

Water loss is always very costly to water utilities. It impacts every part of the utility's business. The water lost, if saved, would result in –

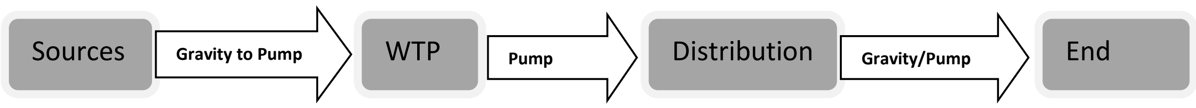
- Less treatment required,
- Less operation finance,
- Reduced debt and depreciation,
- Longer life of existing water resources without the need to supplement,
- Capital deferments,
- Asset life is increased,
- Organizational speed increases,
- Improved measurement knowledge, and
- Positive impact on management success planning and all corporate decisions

It is mostly found that the water loss reduction and the associated revenue loss recovery are among the most promising areas of water resource improvements. Based on a simple assumption of a water loss tariff of 13/m^3 and 19.5/m^3 of water for developing and developed countries, respectively, a total cost[6] of 948.78 billion was estimated for annual water loss around the world.

2.6.2 Energy Conservation

Energy is consumed at every step of water supply scheme. It is used to extract water from source, treat and then distribute the water to the consumers. 5 depicts a typical water distribution system. The raw water from water body is lifted through pumps or gravity from source to water treatment plant. After being treated, the water is then pumped to the ELSR / GLSR which helps in storage and used for distribution further. The water is then pumped or through gravity flows to the consumer end. At every stage, water is transmitted or distributed by pumping which requires electric energy.

Therefore, the leaks and breakages in the distribution system also consumes electricity and incurs costs. Thus, reducing water losses will help save the costs on energy.



Water Distribution System

[6] Water Loss Reduction, Bentley Institute Press (2011)

2.6.3 Reduced Carbon Footprint

Energy consumption due to water loss is increasing the carbon emission, namely the carbon footprint7.

Many large-scale resource development options such as pumped storage reservoirs and distribution are recognized as energy intensive activities in terms of construction and operation.

The studies have shown that the carbon footprint of water losses is proportional to the pressure head and the magnitude of the losses. The greater the pressure head and water loss, the greater the carbon footprint. Reducing water loss directly reduces the carbon footprint.

2.6.4 Social and Environmental Benefits

In addition to reducing the carbon footprint, reducing NRW also gives social and environmental benefits. By actively detecting and repairing leaks, pipeline integrity will be improved to avoid possible contamination ingress; thus, water quality is better assured as leaks are detected and repaired. The improved pipeline integrity will effectively reduce the possibility of pipe bursts. It will thus, minimize the disturbance of social life in local communities.

Reduced water loss also means an increased water supply that allows more people to be served with drinking water. This is particularly important for developing countries like India where there is high water loss and scarce fresh water availability. Research8 suggest that in developing countries, reducing NRW to just half the current level would deliver 8 billion m3 of already treated water to 90 million more people without increasing the demand for endangered water resources. The increased supply with socially uplift the standard of living of people improving their quality of life.

The unauthorized consumption of water resources forms a large chunk of total water loss for a utility. It is important to eliminate the unauthorized use and give fair and equal treatment to all. There are number of tapings thefts and illegal consumption cases, which is a cost to the utility as well as to the authorized consumers. All efforts to remove this will increase revenue efficiency of the utility along with improvement of public reputation and ability to serve its consumers with better facilities transparently.

2.7 CAUSES OF WATER LOSSES

2.7.1 Real Losses

Real losses comprise of leakage from pipes, joints and fittings, through service reservoir floors and walls and from reservoir overflows.

2.7.2 Assessing Real Losses

The real loss assessment methods can be broadly classified into the following two main groups:

[7] Water Loss Reduction, Bentley Institute Press (2011)
[8] Water Loss Reduction, Bentley Institute Press (2011)

2.7.3 Top-Down Real Loss Assessment

In this method, the volume remaining after the volumes of authorized consumption and apparent losses have been deducted from the system input volume is the real loss component. However, this analysis does not provide any information about the components of the total volume of real losses. Also, it does not give information about the quantum of losses due to detectable bursts (which can be reduced by active leakage control) or due to background losses (which can only be reduced by pressure management or infrastructure renewal) in the total real loss.

Despite the simplicity of a top-down type assessment, the leakage estimate obtained via this method is referred to as a crude estimate. So, it is recommended that, the top down annual water balance be undertaken along with the other two assessment methods.

2.7.4 Bottom-Up Real Loss Assessment

Bottom-up assessment calculations are based on analysis of flows into District Metered Areas. This analysis, if carried across the entire distribution system, the areas of high real losses can be identified and prioritized for active leakage control. This method provides an independent determination of the volume of real losses.

Bottom-up type leakage assessment can be considered the second part of the audit process. The audit's main purpose is to find out the efficiency of the water distribution system and the measures needed to achieve these. Bottom-up audits require the most accurate and up-to-date data possible.

Bottom-up real loss assessment can be carried out using following methods:

1. 24 Hour Zone Measurement (HZM)
2. Night Flow Analysis

2.7.5 Apparent Losses

Apparent losses are those that are caused by faulty or badly read meters and meter under-registration, and water that is taken from the network without permission.

2.7.6 Assessing Apparent Losses

Detailed method is covered in below Section.

2.8 ESTABLISHING WATER BALANCE

2.8.1 Determining System Input Volume

The volume of treated water input to that part of the water supply system to which the water balance[9] calculation relates.

System Input Volume = Own Sources + Water Imported

[9] Real Loss Component Analysis by Water Research Foundation

- Own Sources: The volume of (treated) water input to a distribution system from the water supplier's own sources allowing for known errors (for example source meter inaccuracies). The quantity should be measured after the utility's treatment plant(s). If there are no meters installed after the treatment plant, the output must be estimated based on raw water input and treatment losses.
- It is important to note that water losses at raw water transmission pipelines and losses during the treatment process are not part of the Annual Water Balance calculations shown in this report. However, a separate audit of the transmission system and water treatment works can be performed if desired.
- Water Imported: The volume of bulk supplies imported across operational boundaries. Water imported can be either
    - Measured at the boundary meter (if already treated)
    - Measured at the outflow of the treatment plant (if raw water is imported and there is a separate treatment plant)
    - In either case, corrected for known errors (for example transfer meter inaccuracies)
- Mix of raw water: If raw waters imported are mixed with own source raw water in the treatment plant, there is no need for a differentiation and the total production (output) of this one or more plant(s) is used as basis for the System Input. As always, corrections must be made for known errors as with the 'Own Sources', it is important to note that water losses at raw water transmission systems and losses during the treatment process are not part of the Annual Water Balance calculations. In case the utility has no distribution input meters, or they are not used, and the key meters are the raw water input meters, because these are the meters that they buy the raw water on, the system input must be based on the raw water meters and treatment plant use/loss has to be considered

2.8.2 Determining Authorised Consumption

The authorized consumption includes volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so by the water supplier, for residential, commercial and industrial purposes. It also includes water exported across operational boundaries.

Authorized consumption may include items such as firefighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, building water, etc. These may be billed or unbilled, metered or unmetered.

2.8.3 Billed Metered Consumption

All metered consumption which is also billed. This includes all groups of customers such as domestic, commercial, industrial or institutional and includes water transferred across operational boundaries (water exported) which is metered and billed.

2.8.4 Billed Unmetered Consumption

All billed consumption which is calculated based on estimates or norms but is not metered. This might be a very small component in fully metered systems (for example billing based on estimates for the period a customer meter is out of order) but can be the key consumption component in systems without universal metering. This component might also include water transferred across operational boundaries (water exported) which is unmetered but billed.

2.8.5 Unbilled Metered Consumption

The unbilled metered consumption calculation is similar to the billed metered consumption calculation.

2.8.6 Unbilled Unmetered Consumption

Any kind of Authorized Consumption which is neither billed nor metered is called unbilled unmetered consumption. The components typically include items such as firefighting, flushing of mains and sewers, street cleaning, frost protection, etc. Thus, for the calculation of unbilled unmetered consumption, each component needs to be identified and individually estimated. In a well-run utility it is a small component which is very often substantially overestimated.

2.8.7 Calculating Apparent Losses

Includes all types of inaccuracies associated with customer metering as well as data handling errors (meter reading and billing), plus unauthorized consumption (theft or illegal use). It is important to note that reducing apparent losses will not reduce physical water losses but will recover lost revenue. Note: Over-registration of customer meters, leads to under-estimation of Real Losses. Under-registration of customer meters, leads to over-estimation of Real Losses.

Apparent Losses = Un-authorized Consumption + Metering Inaccuracies

2.8.8 Un-authorized Consumption:

Unauthorized consumption can include:

1. Illegal connections
2. Misuse of fire hydrants and firefighting systems
3. Vandalized or bypassed consumption meters
4. Corrupt practices of meter readers

Estimation of unauthorized consumption is a very difficult task. A DMA or pilot area representative of the network can be used as a basis for finding unregistered and illegal customers, and also vandalized and bypassed meters.

2.8.9 Metering Inaccuracies:

The extent of consumer meter inaccuracies whether under- or over-registration has to be estimated based on tests of representative sample of meters. The composition of the sample should reflect the various brands and age groups of consumer meters.

2.8.10 Calculating Real Losses

Real losses are physical water losses from the pressurized system and the utility’s storage tanks, up to the point of customer use. In metered systems this is the customer meter. In unmetered situations this is the first point of use within the property. The annual volume lost through all types of leaks, breaks and overflows depends on frequencies, flow rates, and average duration of individual leaks, breaks and overflows.

2.8.11 Overall Water Balance

System Input Volume	Authorized Consumption	Billed Consumption	Billed Metered Consumption	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Consumption	Unbilled Metered Consumption	Non-Revenue Water
			Unbilled Unmetered Consumption	
	Water Loss	Apparent Losses	Customer Metering Inaccuracies	
			Data Handling Errors	
			Unauthorized Consumption	
		Real Losses	Leakage on Mains Pipes	
			Leakage and Overflow on Tanks	
			Leakage on Service Connections	

2.9 NRW REDUCTION STRATEGY

Understanding different components of NRW, their causes and effects is the cornerstone to successful NRW reduction program. Figure 9 gives a holistic framework and process for NRW reduction. It has four key components:

- **Base Map and Audit:** As the first step, it is important to have all water asset information properly documented, conduct detailed water audit and establish water loss reduction goals; this will help keep the water management staff informed and guided.
- **Source side R&M and Metering:** Source or supply side water network from raw water lifting to ELSRs is relatively better visible, known and has relatively lower NRW share. This section of water can be taken up for dedicated leakage identification, repair and bulk metering.
- **Apparent Loss Reduction:** Apparent loss or Commercial loss primarily surface on the distribution side at the end-consumer interface with water network and will require improving water utility functions including new service connection, regularisation, metering, billing and collection.
- **Real Loss Reduction:** Most part of the NRW Physical loss is on distribution side after the ELSRs, and it is this part that is less known and requires elaborate and systematic leakage detection, repairs and pressure management in smaller decentralised DMAs. Advanced computation tools linking network maps to hydraulic modelling and simulation in combination with strong field measurements and execution can give further speed to leakage detection. Leak detection and repair should be a continuous process throughout the water distribution system's lifetime.

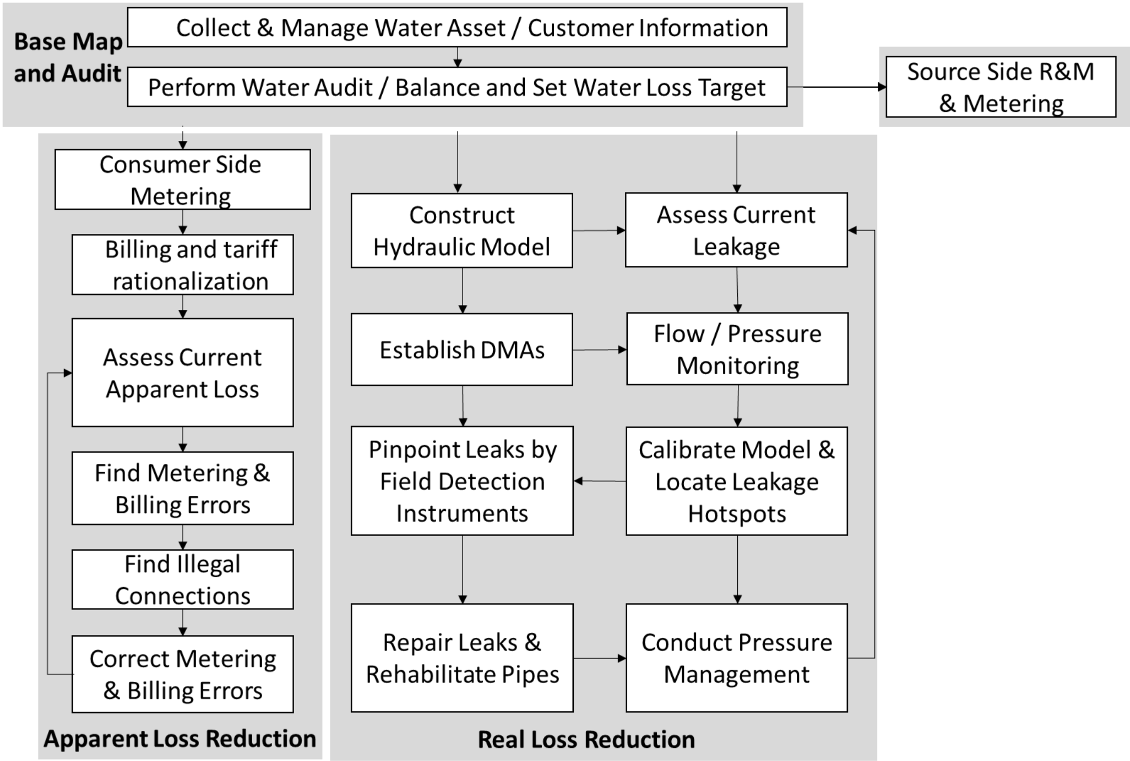


Figure 9: Flow Chart for NRW Reduction

Above approach is an ideal state and should be taken up by MCT Water Supply System, to maintain global benchmark of NRW value. These are standard set of activities to be undertaken as a continuous process by prevention, correction and proper operation and maintenance to attain 24 X 7 water supply.

2.9.1 Base Map and Audit

2.9.1.1 Collect and Manage Water Asset and Customer Information

The first set of activities involve doing GIS mapping, preparing network base maps, conducting topographical and consumer door-to-door surveys.

2.9.1.2 Preparation of Network Base Maps

The digital elevation model (DEM) is a raster-based digital dataset of the topography of all or part of the Earth. The pixels of the dataset are each assigned an elevation value, and a header portion of the dataset defines the area of coverage, the units each pixel covers, and the units of elevation (and the zero-point). DEMs may be derived from existing paper maps and survey data, or they may be generated from new satellite or other remotely sensed radar or sonar data.
Once DEM is prepared all available network data should be transposed as overlays using AutoCAD software. A complete set of network maps covering the entire area of supply should be built up. All data capture would initially be carried out by walking along streets with the local valve operators and oral enquiry. Trial excavations will be needed at critical locations to confirm pipe diameters, materials. Locations of all valves and other properties should be marked. This shall be an ongoing process to increase reliability of data. Any built drawings of the new networks as available should be integrated into the network map. A simple format in local language for capturing leak repair data may be instituted and insisted upon and as the data is reported from each leak the respective asset data shall be corrected and validated.

2.9.1.3 Set up of GIS platform

GIS platform shall integrate the hardware, software, and data management process for capturing, managing, analyzing and displaying all forms of geographically referenced information for the water network. GIS shall allow the user to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

GIS can link the asset and infrastructure information of the entire water supply scheme with consumer data including metering, billing, collection and complaints data.

2.9.1.4 Topographical and Customer Door-To-Door Survey

A ground profiling topo-survey using Total Station equipment shall capture all the ground features like road width, property boundaries, valve chambers, transformers, trees, culverts etc. including spot elevations of each of the water supply or sewerage node.

A geographic information system (GIS) can recognize and analyze the spatial relationships that exist within digitally stored spatial data. These topological relationships allow complex spatial modelling and analysis to be performed. Topological relationships between geometric entities traditionally include adjacency (what adjoins what), containment (what encloses what), and proximity (how close something is to something else).

2.9.1.5 Asset Management

Asset management is good engineering and business practice, and it spans different aspects of utility management and operations, and it starts with good data management. Good asset management is a necessity for long-term economic leakage management, and the objective is to tackle leaks in the most cost-effective way. The critical factors of asset management are:

- Understanding how assets are currently performing
- Collecting data and turning it into useful information for planning
- Good information systems

Particularly relevant to developing an NRW reduction strategy is the aging of the pipe network and making decisions on when to replace or renew the network infrastructure. This requires an understanding of the assets' conditions and deterioration rates. Burst frequency modelling, using data from burst records, helps prioritize pipe rehabilitation, renewal, or replacement. In addition, active leakage control will identify clusters of pipes in the network where bursts and repairs are a continuous occurrence. When these activities do not lead to reduced leakages, utility managers should undertake a condition assessment program to decide whether to replace pipes or conduct further repairs.

2.9.2 Perform Water Audit / Balance and Set Water Loss Target

2.9.2.1 Establishing the strategy development team

The NRW reduction strategy team ensures that all components of NRW are covered and that the proposed strategy is feasible in terms of physical application and financial requirements. The team should comprise of members from each operational department, including production, distribution, and customer service. It may also include members from the finance, procurement and human resource departments. Choosing the right members promotes ownership by the utility's various departments involved in the strategy's implementation, and ensure consensus by senior management.

2.9.2.2 Consumer awareness

One of the goals of reducing NRW is also to provide better and more efficient services to the public. To accomplish this, the public must also understand how they can help manage NRW by reporting burst pipes, faulty valves, leaks, or other problems that limited utility crews may not detect. The earlier the utility becomes aware of a burst pipe or leak, the faster it will be repaired, thus reducing the losses. Awareness programs should be organized with a variety of stakeholders from the public, including politicians, community leaders, and household and industrial consumers. Programs generally focus on basic NRW concepts and how reducing NRW helps ensure that communities receive better water supply and services. After awareness programs are conducted in each community, all staff should work to ensure that customer confidence in the utility's services is maintained. A key element in this is open communication. For example, the public should be able to easily contact the utility to report burst pipes, leakages, or other concerns. The utility should establish a system to receive information or complaints from customers, and then to disseminate it to the relevant operational units so action is taken quickly.

2.9.2.3 Setting the targets and measurement indicators

The selection of outcome indicators and target values is more an art than a science. The process must account for the project's objectives and scope, the level and reliability of baseline information, engineering calculations regarding the amount of reduction that can be expected, and the feasibility of measurement. The most common indicator is the NRW volume, with a specific reduction target designated in terms of m^3/day, or m^3/connection/day. However, if the utility is also trying to expand coverage at the same time as reducing NRW, the indicator must be adjusted for network or customer growth, and perhaps also for pressure changes. This is an important exercise that will benefit from expert advice.

In some cases, adjusting NRW volumes to account for intermittent supply and changes in pressure can become too challenging. Thus, some contracts whose primary objective is to increase the hours of supply (continuity) have opted to measure and reward performance based on this indicator. The reduction of losses is indirectly captured by the increase in the hours of supply, where no new sources of water are introduced into the system.

2.9.2.4 Technology transfer, Training and Staff Awareness[10]

Training staff in new skills and techniques features highly in developing a leakage management strategy ensuring sustainability. It encompasses the motivation of staff, transfer of skills in the techniques and technology of leakage management, and system operation & maintenance. There is a need to address the tasks, the problems and the constraints associated with introducing a leakage management program at all levels within the company. It is important that an understanding of the principles of the program, the steps in its design and implementation, and support for the tasks involved, filters down from senior management level to operations level. A training program will therefore include; awareness seminars for senior staff and decision makers (and to raise public awareness), training workshops for engineering and technical staff and continuous practical training for operations staff.

[10] http://www.gcww.com.eg/_include/images/showcase/Book/Water-reduction.pdf

2.9.3 Source Side R & M and Metering

2.9.3.1 Maintenance of service reservoirs

- Service Reservoirs (SRs) must be inspected regularly and the line department can prescribe frequency of inspections.
- Leakage from structure of SR and through the pipes and valves must be attended to on priority. It is advisable to resort to pressure grouting to arrest leaks from structures and sometimes an additional coating of cement mortar plastering is also done using water proof compound to arrest leaks from the structure
- Maintenance is concerned with mainly protection against corrosion both externally and internally. Corrosion of roof slab of RCC reservoirs because of chlorine is also common. Internal corrosion is prevented by cleaning and painting at regular intervals. Quite Toxic paints should not be used for painting interior surface of SRs. food grade epoxy painted shall only be used for internal surface of SRs. Anticorrosive painting (epoxy) is also done to the interiors when corrosion due to chlorine is expected. Painting of steel tanks once in a year and external painting with waterproof cement paint for exteriors of RCC Tanks once in 5 years is usually done. The inside of painted SR shall be disinfected before putting into use for a period sufficient to give chlorine residuals of at least 0.2 mg/l. Manhole covers & vent pipes shall always be properly placed and maintained
- The maintenance procedures shall include step by step procedure for every piece of equipment in SRs such as pipes inside the tank (In-let, out-let, wash-out, over-flow) valves, specials and flow meters following the procedures as per the manufacturers' catalogues:
- Pipes (In-let, out-let, wash-out, over-flow) and specials
- All the pipe fittings should be leak proof, any leakage nearby reservoir may affect the safety of reservoir
- Overflow pipe should relate to the distribution system after the sluice valve installed on delivery pipeline.
- Concrete platform as protection works shall be provided around the service reservoir, if not provided, to safeguard the reservoir foundation from any leakages/overflow of water
- Valves
- All valves should be inspected regularly in specified frequency of inspection and following activities shall be undertaken.
- Lubrication is required to be done regularly
- Spindles that develop leaks should be repacked
- Rust and sediment in the valve is removed by shutting the disc hard in the seat, then opening about a quarter way and closing tightly several times; the increased velocity usually flushes the obstructions away
- Valve chambers of the SR also require maintenance to ensure that the interiors of chambers are not silted up and ensure that the covers are in good condition and are in position.
- Sluice valve chamber shall not be water logged
- Cleaning of reservoirs

Routine inspection is the best way to determine when a tank requires maintenance and cleaning. A visual inspection can be made from the roof manhole with water level lowered to about half full or less. Alternatively, a detailed inspection can be made after draining the tank and then cleaning or washing. Best time of the year to take up cleaning of SRs is during the period of lowest water consumption.

The following activities are normally involved in cleaning of a tank/SR:

- Make alternate arrangement for water supply to consumers served by the SR.
- Close the inlet line before commencing cleaning of SR.
- Do not empty S.R. and always keep minimum water level at 200-300 mm in the SR.
- Close the outlet valve so that no water will be used while the tank is being cleaned.
- Drain and dispose of the remaining water and silt.
- Wash the interior of tank walls and floor with water hose and brushes.
- Inspect the interior of walls and ceiling of tank for signs of peeling off or deterioration.
- Apply disinfectant (Supernatant of Bleaching powder) to the walls and floor before start of filling the tank/SR.
- The higher frequency of cleaning of SR depends on the extent of silting, development of bio films and results from water quality monitoring. Generally cleaning of Service Reservoir may be periodically done.
- Date of last cleaning and the next due date of cleaning may be displayed on the outer surface of the SRs.

2.9.3.2 Operation and Maintenance (O&M)

O&M is crucial to the successful management and sustainability of water supply networks, whatever the level of technology, infrastructure, and institutional development. It requires forward planning and technology transfer at all stages from installation of plant and equipment, through operator training and hand-over, to routine operation and upkeep. O&M therefore encompasses equipment selection, spares purchasing and repair procedures as well as best practice in operating and maintaining the system. It is essential that an O&M program is built into the project from an early stage and not as an afterthought.

2.9.4 Apparent Loss Reduction

2.9.4.1 Consumer Side Metering

2.9.5 Installing meters properly

Meters should be installed properly according to the manufacturer’s specifications. For example, some meters require a specific straight length of pipe upstream and downstream of the meter. Therefore, a standard meter stand should be designed and constructed onsite. Utilities should purchase the meters on the customers’ behalf, so that only standard, high quality meters are used. Meters should also be installed where meter readers can easily read them, and where it is easy to identify each property’s meter. In addition, the management and staff responsible for meter installations should be trained on proper handling of meters. Meters should be installed at every processing stage to measure the water lost in the process.

2.9.6 Sizing meters properly

Customer meters work within a defined flow range, with the maximum and minimum flows specified by each manufacturer. Large meters will not register low flows when the flow rate is lower than the specified minimum. Therefore, utilities should conduct customer surveys to understand the nature of each customer's water demand and their likely consumption. This information helps to determine the proper meter size for households and businesses. For customers with a high demand, checking the flow pattern and the newly installed meter verifies whether the correct meter size is used.

2.9.7 Use of appropriate type and class of meter

Choosing the appropriate meter helps to ensure the accuracy of customer consumption data.

2.9.8 Metering

a) Multi-jet Meters

The multi-jet water meter is used both in the domestic and the industrial field. The principle of operation is to force the passage of the inlet water flow through a series of ducts open in a capsule, called distributor, containing the turbine. The entrance of the water through the ducts generates a series of symmetrical jets that impact the turbine keeping it in perfect balance.

<u>Example of key brands for multi-jet meters</u> – Elster, Itron, etc.

The most common type of meter for domestic and small commercial installations is the 15 mm and 20 mm PD meter. Single-jet and multi-jet meters are more accurate for small commercial and industrial installations that require 20 mm to 50 mm sizes. Electromagnetic meters are the best choice for sizes 100 mm and above.

b) Class of meters – A, B, C, D

- The Class does not indicate the accuracy of the water meter but the flow rate at which the water meter meets the common accuracy figures. These are ± 5% at the minimum flow rate and ± 2% in the meter's normal range for cold water meters
- The figures for hot water meters are greater at ± 6% and ± 3% respectively
- The higher the class designation (A to D) of water meters the higher the accuracy at very low flow rates with Class D having the highest accuracy, and class A the lowest
- When deciding if a low flow reading is required even a class A will start to read, within its tolerance band, at a flow rate of 1.66 l/m (e.g. 12.5mm basin tap will have a flow rate of between 6 and 10 l/m)
- If the only requirement is an overall indication of the amount of water used, then a class A or B meter is sufficient.
- If the total of secondary meters should relate very closely to a master meter, then a Class C meter should be used.
- Class B meters are a good choice where water quality is low, as the sediments will not greatly affect the meter
- Class D meters are more preferable where roof tanks are used, and water quality is good, since they have a lower minimum flow specification and will measure the roof tank inflow more accurately
- Class C meters are a suitable compromise in most situations, since they can measure low flows better than Class B meters and are not as expensive as Class D meters

Overall, Class D meter offers best configurations with accuracy results.

2.9.9 Billing and Tariff Rationalization

2.9.9.1 Rationalization of tariff[11]

Financial sustainability is a key success factor in any reform process. The service suffers due to unavailability of adequate funds.

Tariff should be rationalized in such a way that full cost recovery is obtained. This implies that Opex costs as well as capex costs should be recovered. Opex involves operations and maintenance costs and capex involves debt and depreciation costs. Appropriate tariff rates facilitate availability of revenue for NRW reduction activities.

Various policy parameters that can be considered for tariff setting are as follows:

- Setting quantity of water, as life line consumption to be made available on affordable prices
- To define higher consumption level beyond which O&M Recovery and full cost recovery is to be made
- To define very high consumption level beyond which full cost recovery plus suitable (15% to 30%) surcharge is to be levied
- Level of NRW to be considered for calculation of unit cost of water (per KL)
- Level of pumping operation efficiency to be considered for calculating unit cost of water (as % of the theoretical best efficiency)
- Tariff to be based on LPCD in place of KL.

2.9.9.2 Smart Meter Billing System

Smart meter billing system can be defined as Data management facility at the utility company that can validate data, has the capacity to store the high volume of data received, and that interfaces with the existing billing system, and is accessible to customer service representatives and to the customers.

2.9.9.3 Assess Apparent Loss

Apparent Losses is always a challenging task to estimate. Unauthorized consumption estimation should be done in a transparent, component-based way so that the assumption can be easily checked and / or modified later. A DMA or pilot area representative of the network can be used as a sample for finding unregistered and illegal connections.

For consumer metering inaccuracies and data handling errors, large customer's meters are usually testing by a test rig. Based on the accuracy tests, average meter inaccuracy values will be established for different user groups.

2.9.10 Monitoring intermittent water supply

Where water supply is intermittent, i.e. the customer receives water only a few hours a day, customer meters will register a certain volume of air when the water supply is first turned on. In addition, the sudden large increase in pressure can damage the meter's components.

[11] http://stsinfra.com/assets/Water%20Tariff%20Rationalization.pdf

Intermittent supply should be avoided for a number of reasons, including the negative impact on customer meter accuracy.

2.9.11 Maintaining and replacing meters properly

All meters should be installed above ground and located where they can be audited easily, including by the meter readers during their regular rounds. The utility should replace the meters systematically, beginning with the oldest meters and those in the worst condition. Poor maintenance will not only encourage inaccuracy but may shorten the life span of the meter. A scheduled maintenance and replacement program should be in place to manage this problem. The water utility should regularly test a sample of its customer meters, including a range of meter brands and ages, using a calibrated meter test bench. This testing will determine the optimum age at which customer meters should be replaced.

2.9.12 Addressing meter tampering

Customers sometimes tamper with their meters to lower the measured volume. Utility managers should conduct customer surveys to assess expected water usage according to the number of household occupants or the nature of businesses in commercial areas. A comparison of expected and actual water use will highlight cases of likely meter tampering. Utility should increase use of tamper resistant meters.

2.9.13 Meter reading errors

Errors can be easily introduced through negligence, aging meters, or even corruption during the process of reading the meters and billing customers. Incompetent or inexperienced meter readers may read the meter incorrectly or make simple errors, such as placing a decimal in the wrong place. Dirty dials, faulty meters, and jammed meters can also contribute to meter reading errors. The meter readers should immediately report any observed problems, and the maintenance team should act to remedy the problem immediately. If remedial action is too slow, meter readers may become demoralized and less inclined to report problems. Because meter readers are the utility’s frontline in liaising with customers, their activities have an immediate impact on cash flow. Utility managers should therefore invest in training and motivating their meter readers to record and report information effectively and efficiently. The manager should also establish systems and procedures to prevent meter reading errors by improving its meter reading and billing processes through greater supervision of meter readers, implementation of rotating reading routes, and frequent spot checks.

2.9.14 Data handling and accounting errors

The typical method of data handling and billing requires a meter reader to visit each property and read the customer meter. The data is then recorded by hand on a form, taken back to the office, given to the billing department, and typed into the billing system. A bill is then printed and mailed to the customer. In this scenario, a variety of errors may occur at the different stages: the meter reader writes down incorrect data; the billing department transfers incorrect data into the billing system; or the bill is sent to the wrong address. A robust billing database is one of the key elements of minimizing these errors and should be the initial purchase of any water utility striving to improve its revenues. The latest billing software has built-in analysis functions that can identify potential data handling errors and report them for verification. In addition, billing software will report monthly estimate readings and zero reads, both of which may indicate a problem with the customer's meter.

2.9.15 Find Illegal Connections

2.9.15.1 Finding and reducing illegal connections

Illegal connections involve the physical installation of a connection to water distribution pipelines without the knowledge and approval of the water utility. Illegal connections can occur during the installation of a new supply connection, or sometimes the customer's supply is cut off after non-payment and the customer cannot afford, or does not want to pay, to be reconnected. During customer awareness programs, customers should be encouraged to report illegal connections, and regulations should be in place to penalize the water thieves. Meter readers should also report cases of direct connections without accompanying meters that they see during their rounds.

2.9.15.2 Tackling meter bypassing

Some customers try to reduce their water bills by using a meter bypass, which is an additional pipe installed around the meter. This bypass pipe is often buried and very difficult to detect. This type of unauthorized consumption is usually committed by industrial and commercial premises to steal large volumes of water. The discrepancy will show up when the utility conducts a flow balance analysis. The utility should then undertake customer surveys and leakage step tests to determine where the missing flow occurs.

2.9.15.3 Preventing illegal use of fire hydrants

Although the only legal use of fire hydrants is for firefighting, some use them illegally to fill tankers (normally at night) or to provide water supply to construction sites. The utility staff can detect these flows, often high volume over a short period of time, through appropriate flow measurements at DMA meters. Such high flows are not only incidences of water theft, but also a detriment to the pipe network and water quality, which affects the service to the customer. Through customer awareness programs, the utility staff should encourage customers to report cases of illegal uses of fire hydrants. Developing and enforcing regulations to penalize water thieves together with local agencies will also deter unauthorized consumption.

2.9.16 Correct Metering and Billing Errors

2.9.16.1 Avoiding corrupt meter readers

Corrupt meter readers can significantly impact a utility's monthly billed consumption. For instance, the same meter reader who walks the same route for an extended period of time, thus becoming familiar with the customers and their monthly billed consumption, may collude with those customers to record lower meter readings in exchange for a monetary incentive. To reduce this risk, the utility manager needs to rotate meter readers to different routes on a regular basis.

2.9.16.2 Actively checking the customer billing system

Sometimes connections are made legally, but the billing department is not notified of the new connection; therefore, the customer is never billed. These unregistered customers can be detected during the regular meter reading cycle when diligent meter readers find meters that are not in their reading book. However, this process may not identify all of the errors in the billing system. Conducting a complete customer survey within each DMA, whereby utility representatives visit every property in the DMA—whether or not they are recorded in the billing system—is the best method of comprehensively identifying billing system errors. The survey should include the following information: property address, name of owner, and meter make and number. The representative should also conduct a meter test to ensure that the accurate flow is recorded. For metered areas, utilities should focus on large users by encouraging good customer relationships through frequent visits. Checking large customers' accounts monthly will help detect anomalies, which may be due to water theft. In areas of suspected high commercial losses, temporary DMAs can be established to analyze flows through standard monitoring activities, such as step testing and flow balancing, to pinpoint problematic areas.

2.9.16.3 Improving bill collection efficiency[12]

Tightening enforcement of collections policy may improve customer satisfaction at utilities. Customer service satisfaction is higher at the utility that strictly enforces their collections policy and has lower bad debt write-offs. Utilities that consistently enforce their collections policy spend less time interacting with delinquent customers, leaving more time to provide high-quality customer service. Staff availability to service paying customers could be the key source of increased customer satisfaction. Additional benefits of a consistently enforced collection policy include higher revenue and lower customer operations costs, both of which help keep water rate increases in check.

The best practices for improving collections are as follows:

The best practices for improving collections are as follows:

a) Collect and Maintain Good Customer Data
b) Practice premises-based billing
c) Employ Customized, Risk-Based Processes
d) Make it Easy to Pay
e) Leverage State Laws and Local Ordinances
f) Make Utilities Accessible

2.9.17 Real Loss Reduction

2.9.17.1 Construct Hydraulic Model

This is required to simulate the operation of the real network in all its key elements. In Indian water utilities, network future design is often interpreted as hydraulic modelling. The design is primarily for sizing of pipes for future projected demand capacities. Hydraulic modelling is simulating the network for the current consumption pattern which is developed through an iterative simulation process duly capturing the flow and pressure data of the current network functioning scenario. When the network has been properly calibrated, it enables the current operation of the network to be fully understood, identify anomalies and most importantly optimize the design of any modifications to the configuration of the network before they are created in the field, thus assuring pipes are correctly sized and customer complaints are avoided.

2.9.17.2 Brief on Hydraulic Modelling:

GIS based study of existing water supply system and analysis using international standard design software. It is the calibration of distribution network to find out lacunas in the system. It involves

[12] http://www.energycentral.com/c/um/six-best-practices-utilities-can-employ-improve-collections-performance

preparation of rehabilitation plan for existing system while additional components were proposed to cater the demand of future population.

Hydraulic modelling which is heart of water network is used to evaluate important elements of free surface fluid flow. Generally, hydraulic modelling can refer to both numeric modelling (in which a simulation is performed on a computer), or physical modelling (where the physical flow geometry is scaled in such a way that it can be modelled in the laboratory). Numeric models are usually two- or three-dimensional, whereas physical hydraulic models are always three-dimensional. Geometry is sometimes easier to manipulate and modify in a numeric model, and wider areas (larger volumes) can often be more cost-effectively simulated in a numeric model. Physical hydraulic modelling, however, must be used when unsteady vortex dynamics is a concern, such as in pump or turbine intakes. Hydraulic modelling is often most cost effective when the two methods are used together, simulating wide areas with a numeric model, using results to develop boundary conditions for a smaller physical hydraulic model in locations where vortexing or some other physical phenomena not easily captured by numeric modelling is of interest.

Hydraulic models are often used to validate the design of new or rehabilitated pipelines. They are also used to verify the system capacity or to analyze the effect of modified infrastructure within the context of the entire water distribution system or its sub-system. They provide understanding of the distribution system such as flow patterns and pressure variations. It can also simulate impacts of new customers. It helps in identifying the operation and maintenance needs and future improvements.

To develop Hydraulic model, GIS mapping is required along with historical data, network and physical data and field data. Physical information such as dimensions, main sizes, connectivity, mapping, closed valves, pump curves, control valves locations are required. Water demands of residential, commercial, industrial, wholesale consumers are also required.

2.9.17.3 Establish DMAs

The establishment of DMAs involves sub-division of network into DMAs supplied by a limited number of key mains on which flow meters are installed. DMA approach is incorporated to a specific area typically to gauge details on a sample area with certain qualifying criteria. Each DMA is a hydraulically separate portion of the network.

Once the DMA has been established, it becomes an operational tool for monitoring and managing both major components of NRW, physical and commercial losses.

2.9.17.4 Pinpoint Leaks by Field Detection Instruments

There are several modern technologies that employ insertion meters to identify leaks by measuring fluctuations in flow. Leak pinpointing to a small area and then to the actual point for excavation is carried out using combination of one or more of the following pieces of equipment,

1. Basic (acoustic) listening stick
2. Electronic sounding stick
3. Ground microphone (or an “array” of microphones laid along the line of the pipe)
4. Leak noise correlator
5. Noise Loggers
6. Gas Tracing Methodology

2.9.17.5 Repair Leaks and Rehabilitate Pipes and Other Assets

Existing leaks and pipes should be repaired considering life of the assets as well as using latest technologies.

2.9.18 Assess Current Leakage

2.9.18.1 Awareness, Location and Repair (ALR)

Real losses comprise of leakage from pipes, joints and fittings; through service reservoir floors and walls and from reservoir overflows. They can be severe and may go undetected for months or even years.

The volume lost will depend on the characteristics of pipe network, the leak detection and repair policy practiced by the utility other factors such as:

- Pressure in the network
- Frequency and typical flow rates of new leaks and bursts
- Proportions of new leaks that are reported
- The level of background leakage

The level of leakage due to both reported and unreported bursts will depend on time for which they run. The run time comprises of following three elements:

- Awareness time—time required for the utility to become aware of the leak
- Location time—time required to locate the leak
- Repair time—time required to repair the leak

The volume of water lost will continue to increase until the water utility is aware of the problem, locates or pinpoints it, and finally repairs or resolves it. Therefore, the NRW strategy must ensure that the company reduces its awareness, location, and repair times for all NRW components. Many losses occur because of poor or limited maintenance, so in addition to reducing ALR, a fourth element of the NRW strategy should be system maintenance. This is critical to maintaining incidence of new leaks, meter failures, reservoir leaks, and other problems.

2.9.18.2 Active leakage control (ALC)

Active leakage control (ALC) is vital to cost-effective and efficient leakage management. The quicker the operator can analyze DMA flow data; the quicker bursts or leaks can be located. This, together with speedy repair, limits the total volume of water lost.

2.9.18.3 Regular survey

Regular survey is a method of starting at one end of the distribution system and proceeding to the other, using one of the following techniques:

- Listening for leaks on pipework and fittings
- Reading metered flows into temporarily zoned areas to identify high-volume night flows
- Using clusters of noise loggers

2.9.18.4 Leakage monitoring

Leakage monitoring is flow monitoring into zones or district metered areas (DMAs) to quantify leakage and to prioritize leak detection activities. This has now become one of the most cost-effective activities (and the one most widely practiced) to reduce real losses. The most appropriate leakage control policy for a utility will mainly be dictated by the characteristics of the network and local conditions, which may include financial constraints on equipment and other resources.

It is a methodology which can be applied to all networks. Even in systems with supply deficiencies, leakage monitoring zones can be introduced gradually. One zone at a time is created and leaks detected and repaired, before moving on to create the next zone. This systematic approach gradually improves the hydraulic characteristics of the network and improves supply. Leakage monitoring requires the installation of flow meters at strategic points throughout the distribution system, each meter recording flows into a discrete district which has a defined and permanent boundary. Such a district is called a district metered area (DMA). A leakage monitoring system will comprise a number of DMAs where flow is measured by permanently installed flow meters. The DMA meters are sometimes linked to a central control station via telemetry, so that flow data are continuously recorded.

Analysis of these data, particularly of flow rates during the night, determines whether consumption in any one DMA has progressively and consistently increased, indicating a burst or undetected leakage. It is important to understand the composition of night flow, as this will be made up of customer use as well as losses from the distribution system. DMA maintenance is crucial to maintain the accuracy of the data. It includes maintaining the integrity of the DMA boundary as well as plant and equipment, i.e. it involves checks on the accuracy of meters and secondary instrumentation.

2.9.19 Leak localizing

Once the network is divided into DMAs, those showing a greater volume of night flow per connection than the others, can then be inspected more thoroughly by carrying out a leak localizing exercise. Inspectors can then be deployed to locate the precise leak position in the culprit section of pipe. Examples of these are:

- Step test – a technique which requires the progressive isolation of sections of pipe by closing line valves, beginning at the pipes farthest away from the meter and ending at the pipe nearest the meter. During the test the flow rate through the meter is observed, and the times when each section of pipe is isolated are noted. A large decrease in flow, or “step”, indicates a leak in the section of pipe which has just been isolated.
- Correlator survey
- Acoustic logger survey (sometimes combined with correlation)

2.9.20 Flow/Pressure Monitoring

2.9.20.1 Supervisory Control and Data Acquisition

To enable appreciable metering in Municipal Corporation of Lucknow water supply scheme, SCADA systems can be deployed in the distribution system.

Supervisory control and data acquisition (SCADA) is a control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management, but uses other peripheral devices such as programmable logic controllers (PLC) and discrete PID controllers to interface to the process plant or machinery. The operator interfaces that enable monitoring and the issuing of process commands, such as controller set point changes, are handled through the SCADA supervisory computer system.

However, the real-time control logic or controller calculations are performed by networked modules which connect to the field sensors and actuators.

A SCADA system usually consists of following main elements:

- Supervisory computers

This is the core of the SCADA system, gathering data on the process and sending control commands to the field connected devices. It refers to the computer and software responsible for communicating with the field connection controllers, which are RTUs and PLCs, and includes the HMI software running on operator workstations. In smaller SCADA systems, the supervisory computer may be composed of a single PC, in which case the HMI is a part of this computer. In larger SCADA systems, the master station may include several HMIs hosted on client computers, multiple servers for data acquisition, distributed software applications, and disaster recovery sites. To increase the integrity of the system the multiple servers will often be configured in a dual-redundant or hot-standby formation providing continuous control and monitoring in the event of a server malfunction or breakdown.

2.9.20.2 Calibrate Model and Locate Leakage Hotspots

Calibration of hydraulic models can be described as a 2-step process consisting of,

1. Comparison of pressures and flows predicted with observed pressure and flows for known operating conditions i.e. pump operation, tanks levels, pressure reducing valve settings, and
2. Adjustment of input data for the model to improve agreement between observed and predicted values.

2.9.20.3 Conduct Pressure Management

As system operating pressures are increased or decreased, the volume of annual real losses will increase or decrease proportionally.

Pressure management for leakage control, in its widest sense, can be defined as “The practice of managing system pressures to the optimum levels of service ensuring sufficient and efficient supply to legitimate uses and consumers, while reducing unnecessary or excess pressures, eliminating transient s and fault y level controls all of which cause the distribution system to leak unnecessarily.”

There are a number of important factors that relate to the monitoring of the effectiveness of a Pressure Managed Area (PMA):

- Flow data monitoring – Daily Input volume and Night line monitoring
- Inlet and Outlet Pressure monitoring – indicative of PRV effectiveness, servicing requirement and available night time pressure control
- Burst frequency – Measure of burst frequency before and after installation.
- Reducing the water pressure in a system can be achieved in a number of ways each of which has advantages and disadvantages.

The following techniques are discussed:

- Fixed outlet pressure control
- Fixed outlet pressure control involves the use of a device, normally a pressure reducing valve (PRV) which is used to control the maximum pressure entering a zone.

- PRVs are instruments that are installed at strategic points in the network to reduce or maintain network pressure at a set level. The valve maintains the pre-set downstream pressure regardless of the upstream pressure or flow-rate fluctuations. PRVs are usually sited within a DMA, next to the flow meter. The PRV should be downstream of the meter so that turbulence from the valve does not affect the meter's accuracy. It is good practice to install the PRV on a bypass pipe to enable future major maintenance works.
- Time-modulated pressure control
- The time-modulated pressure management option is effectively the same as the fixed-outlet system with an additional device which can provide a further reduction in pressure during off-peak periods. This form of pressure control is useful in areas where water pressures build up during the off-peak periods – typically during the night when most of the consumers are asleep.
- Flow modulated pressure control
- Flow modulated pressure control provides even greater control and flexibility than the time-modulated option. It will normally provide greater savings than either of the two previously mentioned options but this greater flexibility (and savings) comes at a price. The electronic controller is more expensive, and it requires a properly sized meter in addition to the PRV. It may not always be cost effective to use the flow modulated option and careful consideration should be given to the specific application before selecting flow-modulated control.

It should be noted that there are numerous other forms of pressure control techniques which can be considered when trying to reduce losses from a water distribution system.

3 EXISTING WATER SUPPLY SYSTEM- AS-IS SITUATION

3.1 WATER SOURCES

As per March 2017 Study[13], total water supply of Lucknow city is estimated to be around 467 MLD. Important water resources of the area are river – Sai River and Ganga River, canal, tank / ponds and ground water.

Table 7. Sources of water in LMC

SN	Water Source	Total number
1	Ground Water	ESR: 56
2	Surface Water	ESR: 52
3	Tube wells	708

Future unplanned development of the area will affect adversely the Sai and the Ganga River, ground as well as surface water. At present, domestic waste water from basti areas and existing development along N.H. 25 is being discharged to nearby water body without any prior treatment.

The canal water is also used for washing vehicles and other purposes, which is polluting the canal water. These are the two major water bodies in the area which needs to be focused for conservation and measures to be taken for minimum contamination of the rivers due to industrial nature of the area.

All storm water, domestic and industrial wastewater gets mixed into these drains and gets discharged in Sai and Ganga rivers

3.1.1 Ground water (hydro geological)

Ground water is a major source of water to Lucknow city. As per the study conducted by UP State Ground Water Board, due to excessive extraction and decreasing soft surface, average water table drop is 0.52 mtr. every year.

Tube-wells were planned to operate with 10 HP energy to discharge 1000 lpm. But due to adverse repair conditions and minimal maintenance, as of now they can discharge only 500-600 lpm.

Around 85% of the land area of Lucknow city is situated on the Central Ganga alluvial plain, and stretches across both banks of the Gomti river which is an entirely low land river naturally dependent on ground water discharge for its dry weather flow. Lucknow city resting on a rich alluvial aquifer system of Central Ganga plain, is a glaring example of 'Hydro Geological Stress', where pressure on ground water for drinking water supplies has increased manifold and this has resulted into its continuous and excessive withdrawals.

Zone 5 and 8 have 100% ground water supply.

3.1.2 Surface water

The area lies in Gomti-Sai sub-basin of Ganga basin. The surface water resource is mainly dependent on the river Sai and its tributaries and network of Sharda Sahayak Canal system and

[13] http://environmentclearance.nic.in/writereaddata/Online/TOR/29_Mar_2017_160846230ABMGQHEYLIDAREPORT.pdf

its distributaries. These surface water resources, however, may serve the future urban-industrial needs only partially and future development would depend largely on the ground water resources.

3.2 WATER NETWORK

3.2.1 Production

Gomti River is the major water body in Lucknow with few major canals namely Haider Canal, Kukrail Drain, Sharda Canal etc. Sharda Sahayak Feeder Canal is taken from river Ghagra. Three water works namely Aishbagh, Balaganj and newly constructed Gomti Nagar Water Supply System (80 MLD) are available to treat the water from Sharda Sahayak Feeder Canal. Total capacity of the water works is 545 MLD. Ground water also contributes to the water supply in Lucknow. There are total 605 tube wells in Lucknow city and 65 mini tube wells. Water is supplied through hand pump as well. There are total 9964 hand pumps in Lucknow.

With the objective of reducing utilization of ground water in different zones, Jal Nigam has developed water works to treat surface water and utilize it. As of now there are 3 WTPs constructed with capacities specified below –

1. Aishbagh Water Works - **265 MLD**
2. Balaganj Water Works
    a. Balaganj 1 – **100 MLD**
    b. Balaganj 2 – **100 MLD**
3. 80 MLD Water Works – **80 MLD**

Gaughat raw water pumping station is the major source of surface water in Lucknow city WS. The pumping station contains two separate pumping stations available for water supply to Aishbagh Water Treatment Plant and one pumping station for Balaganj water treatment plant. Four different pipe lines i.e. 1300mm(MS), 1200mm(PSC), 650mm(MS) and 500mm(MS) are derived for Aishbagh water treatment plant. 1300mm and 1200mm dia. pipe line are derived from 1st pumping station and 650mm and 500mm dia. pipeline are derived from 2nd pumping station.

<u>Pumping Stations 1 and 2</u>:
All pumps of pumping station 1 are in working condition. Pumping station 1 has one common pressure monitoring point which is in working condition.

Table 8: Pumping Station 1 and 2 (Aishbagh WTP)

Pump No.	Capacity (HP)	Discharge (m3/hr.)	Head (m)
1	375	2043	35
2	375	2043	35
3	700	4800	35
4	375	2043	35
5	700	4259	35
6	700	4259	35
7	700	4086	35

Source: Lucknow Municipal Corporation

Figure 11: Pumping Station 1 (for 1300mm & 1200mm dia. pipe line)

Figure 10: Pumping Station 2 (for 650mm & 500mm dia. pipe line)

Pumping Station 3:

Balaganj raw water pumping station contains 5 pumps out of which 2 are not in operation. 1200mm and 900mm dia. pipe lines are separately derived from this particular pumping station and runs about 2.0 km. distance up to Balaganj WTP. There are no pressure monitoring points in this pumping station.

Table 9: Pumping Station 3

Pump No.	Capacity (HP)	Discharge (m3/hr)	Head (m)
1	300	2084	27
2	300	2084	27
3	300	2084	27
4	300	2084	27
5	300	2084	27

Source: Lucknow Municipal Corporation

Figure 12: Pumping Station 3

3.2.2 Aishbagh Water Works

3.2.2.1 Headwork's

Raw water from Gaughat pumping station is fed into Aishbagh water works by 7 heavy duty pumps out of which 3 are of 375 HP, 4 are of 700 HP. Four different raw water MS pipes of DN 1300 mm, DN 1200 mm, DN 675 mm and DN 500 mm transfers water from Gaughat pumping station to Aishbagh water works.

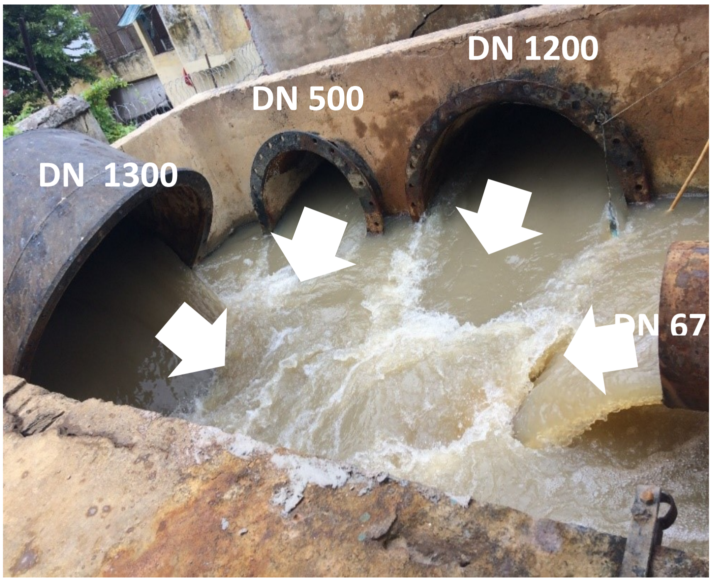


Figure 13 Raw Water Inlet at Aishbagh WTP

3.2.2.2 Water Treatment Plant:

Aish Bagh WTP receives raw water from Gaughat Raw Water intake by four variable transmission pipe lines, then via open channel it is transmitted to four different treatment plants, each treatment plant has eight sand beds, then treated water is supplied for chlorination by open underground channel. This is the only medium to supply treated water to 2 different pumping stations. Pumping Station 1 has 3 pumps (2 – operational, 1 – standby pump). Pumping station 2 has 5 pumps (4 – operational, 1 – standby pump). Pumping station 1 flows through 900 mm line whereas station 2 water flows through 1200 mm line. Overall, the WTP supplies water to zones 1, 2 and 3.

Figure 14 Aishbagh Water Works

Figure 15 Raw Water Supplied from Gaughat Pumping Station

Pumping Station 1:

Pumping station 1 feeds water to different ZPS. The outlet of pumping station1 is through DN 1200 mm pipeline. Figure 16 pumping station is the oldest one and has no data/records on paper or otherwise to identify the pipeline network deriving from this pumping station.

Table 10: Pumping Station 1

Pump No.	Capacity (HP)	Discharge (m^3/hr.)	Head (m)
1	200	1144	35
2	200	1144	35
3	200	1144	35
4	600	4320	35

Source: Lucknow Municipal Corporation

Figure 16: Pumping Station

a) Pumping Station 2:

Pumping station 1 feeds water to different ZPS. The outlet of pumping station1 is through 1200 mm dia pipeline. This pump house is a pressure monitoring point which is in working condition.

Table 11: Pumping Station 2

Pump No.	Capacity (HP)	Discharge (m^3/hr.)	Head (m)
5	450	3645	35
6	450	3645	35
7	450	3645	35

Source: Lucknow Municipal Corporation

Figure 17:Aishbagh Pumping Station 2

b) Pumping Station 3:

Pumping station 3 feeds water to government residential quarters ESR.

Table 12: Aishbagh Pumping Station 3

Pump No.	Capacity (HP)	Discharge (m^3/hr.)	Head (m)
1	150 (Non-functional)	900	35
2	150	900	35
3	150	900	35
4	150 (Non-functional)	900	35

Source: Lucknow Municipal Corporation

Figure 18: Aishbagh Pumping Station 3

c) Pumping Station 4:

Pumping station 4 feeds water to Garhi Kanhora, Rajendra Nagar, Karheta and KKC ZPS. The outlet of the pumping station 4 is through 900 mm dia pipeline. An electromagnetic flowmeter is also installed on this 900 mm dia pipeline of Crone Marshal make, but the meter is not in operation.

Table 13: Aishbagh Pumping Station 4

Pump No.	Capacity (HP)	Discharge (m^3/hr.)	Head (m)
1	300	3500	35
2	300	3500	35
3	300	3500	35

Source: Lucknow Municipal Corporation

Plant 4: This pump house pumps water to Bhadwa ESR only

Pump No.	Capacity (HP)	Discharge (lpm)	Head (m)
1	120	10800	35
2	120	10800	35

Source: Lucknow Municipal Corporation

Figure 19: Aishbagh Pumping Station 4

d) Water Supply

Water is supplied from Aishbagh WTP to 8 Zonal pumping stations through DN 1200, DN 900. DN 750 is sublet of DN 900 pipe. Water from Aishbagh WTP is supplied to zones 1, 2 and 3 which gets a mix supply of treated water and ground water.

Key Challenges:

1. Missing details on alignment of the pipelines: Raw water inlets of Aishbagh are too old pipelines to be able to understand the alignment of the pipelines. After detailed verification, it was found that most of the pipes are going underground beneath several apartments, residential houses and commercial buildings. In such situation, it is difficult to analyse the condition and details of the buried transmission lines.
2. Heavy corrosion / rusting: The deteriorated condition of pipelines has resulted in inconvenience while fixing the portable ultrasonic flow meters to capture measurements.

3.2.3 Balaganj Waterworks

3.2.3.1 Headworks:

Balaganj Water Works also receives water from Gaughat Raw Water Pumping Station through 2 pipelines – DN1200 mm and DN 900 mm. It is supplied water by 5 pumps of 300 HP each which are installed at Gaughat Raw Water Pumping Station.

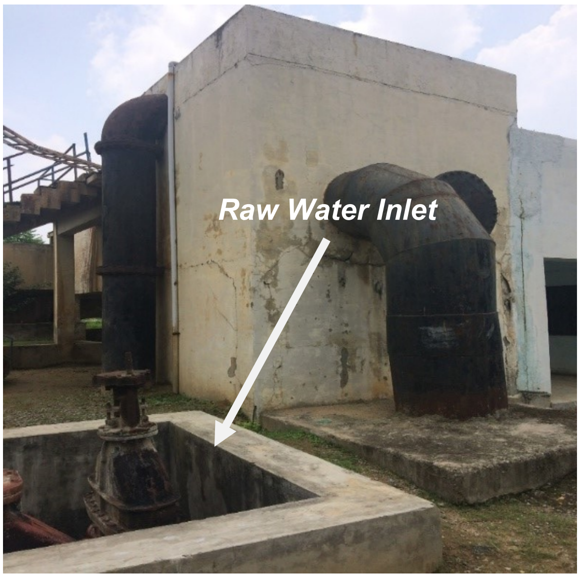


Figure 21: DN 900 Raw Water Inlet at Balaganj

Figure 20: DN 1200 Raw Water Inlet at Balaganj

Figure 22: Water Inlet in Water Works

Figure 23: Balaganj Back Wash

3.2.3.2 Water Treatment Plant:

Balaganj water treatment has two plants of capacity 100 MLD each, therefore overall treatment plant consists 200 MLD of water supply capacity on paper where only two pumps out of 5 pumps are operational resulting in inefficient pumping from the WTP. The plant gets raw water from two inlets – a) 900 mm dia MS and b) 1200 mm dia PSC pipe line. After treatment, clear water goes for chlorination process and finally to the main pump house. After treatment, it is further distributed to different areas through 3 pipelines of DN 700 mm (Chowk), DN 900 mm (Rajajipuram) and DN 900 mm (Kashmiri Mohalla) and are tapped further up to other ZPSs.

Figure 24: Outlet of Balaganj WTP

Below table gives details of Balaganj pump house.

Table 14: Balaganj Pumphouse

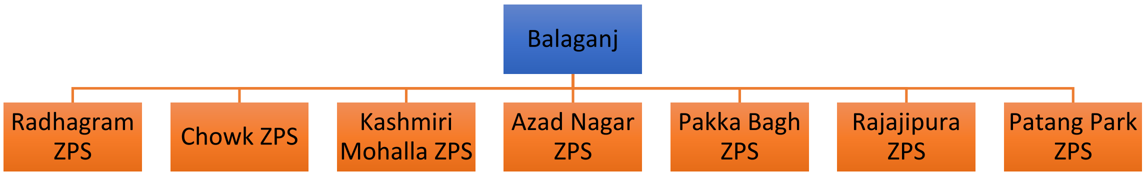
Pump No.	Capacity (HP)	Discharge (m^3/hr.)	Head (m)
1	500	2084	46
2	500	2084	46
3	500	2084	46
4	500	2084	46
5	500	2084	46

Source: Lucknow Municipal Corporation

Figure 27: Leakage in settling tank

3.2.3.3 Water Supply

Water is supplied from Balaganj water works to 7 zonal pumping stations.



From zonal pumping stations, water is further distributed into ESRs which then supplies the treated water to zones 1 and 6 of Lucknow city.

Key Challenges:

There are many leakages found in every section of Balaganj Water Works, from settling tank to outlet. This has resulted in huge losses during the treatment process accounting to about 20-30% total water loss. Below figure refers to the leakage in air valve at the outlet of Balaganj WTP. Gate valves of the majority of the pumps are leaking. There is huge burst in existing air valve on 900 mm dia pipeline which feeds water to Rajajipuram. There are leakages from flange in most of the valves as well.

Figure 29: Leakage in distribution pump

Figure 28: Leakage in Air valve at the outlet

3.2.4 Gomti Nagar Water Supply System (80 MLD)

3.2.4.1 Headwork's

The third water works has Sharda Sahayak Canal as its major source of raw water. Water from Sharda Sahayak Canal is supplied to artificial lake called Chinhat by pumping through DN 1300 mm transmission pipeline. The water is then pumped to 80 MLD WTP through DN 900 mm and DN 1300 mm. Three pumps off 250 HP each are installed at Chinhat lake pumping station through which water is transferred from Chinhat lake to 80 MLD WTP. 900 mm dia pipe line is constantly in use acting as major inlet to this WTP. 1300 mm dia pipe line is used occasionally, only when required. This is a newly constructed treatment plant.

Figure 30: Jal kal Vibhag Zone 4

Table 15: Sharda Sahayak Pumping Station

Pump No.	Capacity (HP)	Discharge (lpm)	Head (m)
1	300	38520	25
2	300	38520	25
3	300	38520	25

Source: Lucknow Municipal Corporation

Figure 31: 80 MLD Pumping Station (left) and Inlet (right)

Figure 32: Gomti Nagar (left) and Indra Nagar (right)

3.2.4.2 Water Treatment Plant

80 MLD water treatment plant is newly constructed. It is fed by Chinhat lake pumping station through DN 900 mm and DN 1300 mm MS pipes. In 80 MLD WTP there are 9 pumps which are internally divided into 3 sections as per the distribution system. 3 pumps of 250 HP each deliver water to Indira Nagar out of which 2 are in working condition and 1 in standby mode. Similarly, 3 pumps of 250 HP each deliver water to Gomti Nagar out of which 2 are in working condition and 1 in standby mode. Vastu and Vinamra Khand is supplied water through 3 pumps of 200 HP each out of which 2 are in working condition and 1 is in standby mode.

Table 16: 80 MLD Pumping Station

Pump No.	Capacity (HP)	Discharge (m^3/hr.)	Head (m)	Frequency
1	200	24900	25	Gomti Nagar
2	200	24900	25	
3	200	24900	25	
4	250	27000	30	Indira Nagar
5	250	27000	30	
6	250	27000	30	
7	30	1800	45	Vastu-Vimnra Khand
8	30	1800	45	
9	30	1800	45	

Source: Lucknow Municipal Corporation

Figure 33: Gomti Nagar 80 MLD

3.2.4.3 Water Supply

Water is supplied from 80 MLD WTP to 13 ZPS and 2 ESR through three MS pipelines DN 650 mm, DN 650 mm & DN 200 mm. From ZPS water is distributed to 49 ESRs. Treated water from 80 MLD WTP is supplied to two zones i.e. zone 4 & 7 (Indra Nagar, Gomti Nagar, Vastu-Vinmra Khand)

3.2.4.4 Transmission

Water from tube wells and treated water reservoirs is drawn using submersible and HSC pumps and conveyed through pumping main to the ESRs and GLSRs and in some cases, directly to distribution. The size of transmission lines from the sources varies from 200 mm dia to 1300 mm dia.

3.2.4.5 Distribution

The distribution line for water supply can be studied in two parts – one as main line distribution and other household connections.

3.2.4.6 Main line

Detailed information is covered in this report.

3.2.4.7 Household Connections

As per the ARV data from Jal Kal department, below are the total number of connections and demand in LMC for different zones.

Zone	# of Connections	Demand (Rs.)
Zone 1	37,592	883,81,790.39
Zone 2	47,066	715,98,847.46
Zone 3	24,304	656,37,116.76
Zone 4	32,208	1162,63,320.41
Zone 5	33,461	569,43,490.44

Zone 6	61,610	828,29,959.06
Zone 7	46,525	1220,84,957.00
Zone 8	49,611	1153,43,926.99
Total	**3,32,377**	**7190,83,409**

Source: Lucknow Municipal Corporation

3.3 CONSUMPTION

3.3.1 Customer Distribution

The billing data doesn't cover information on the distribution of consumers as domestic or non-domestic. Due to very limited information available, this will be covered in subsequent reports after detailed surveys and meetings with the officials, knowledgeable on the subject.

3.3.2 Tariff Structure

The billing structure in LMC follows ARV model. The details of the structure are as below -

Table 17. Tariff Model

Annual Rental Value (ARV)	15 mm	20 mm	25 mm
0 – 360	441	661.5	1029
361 – 2000	588	682	1323
2001 – 3500	882	1323	2058
3501 – 5000	1176	1690.5	2499
5001 and above	1470	2205	2940
	Or 12.5 % of ARV per year, whichever is greater		

Source: Lucknow Municipal Corporation

As per the primary survey and interviews, all domestic connections are of 15 mm dia. pipeline, for commercial consumers, only about 2% of the total commercial consumers have pipe connection with diameter more than 15mm., remaining everyone has 15mm diameter pipe connection.

3.3.3 Tariff Trend and Analysis

The tariff model needs to be assessed and the structure to be followed should be so as to achieve full operating cost recovery in 5 years.

Tariff hasn't been revised since around past 15 years.

Water problems are expected to be a major constraint on sustainable development in some countries in the 21st century. Water pricing is a key tool for overcoming this constraint.

3.4 ECONOMICS

3.4.1 Supply Costs

We performed a research on the as-is situation of operational efficiencies achieved at LMC. We found limited data on public domain and government published reports. It is observed that continuity of water supply which is benchmarked to be 24 x 7 is only achieved 4 hours a day, this provides a big scope for improvement. The information sought after and received is summarized below.

3.4.2 Jal Kal Division

The Jal Kal division operates in two segments: Water & Sewerage, since some of the data needed for dividing the two divisions was not segregated in publicly available budgetary reports, we only looked at the Jal Kal division level. Based on the data available, it can be said that the sewerage department comprises of 10-15% of Jal Kal division.

3.4.3 Operating Expenses of Jal Kal Division[14]

The next assessment we sought after was variances in budgets of the Jal Kal division to give us the idea of operating expenses budgeted and incurred for the water and sewerage facilities. We found that LMC has over budgeted its expenses in past, which can be summarized in the below table. The operating expenses incurred year over year can be used as a good benchmark to understand the trend and costing.

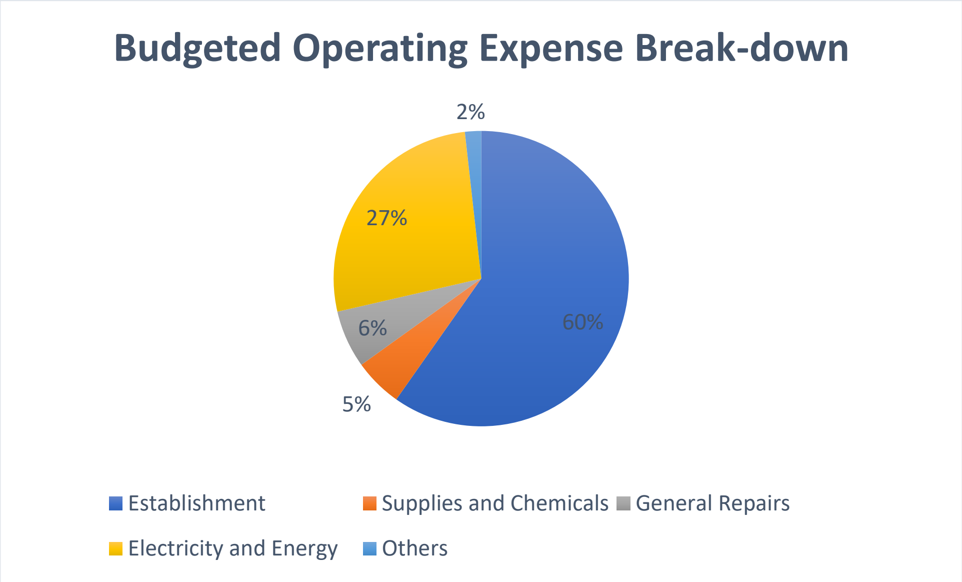
Table 18: Operating Expenses of Jal Kal

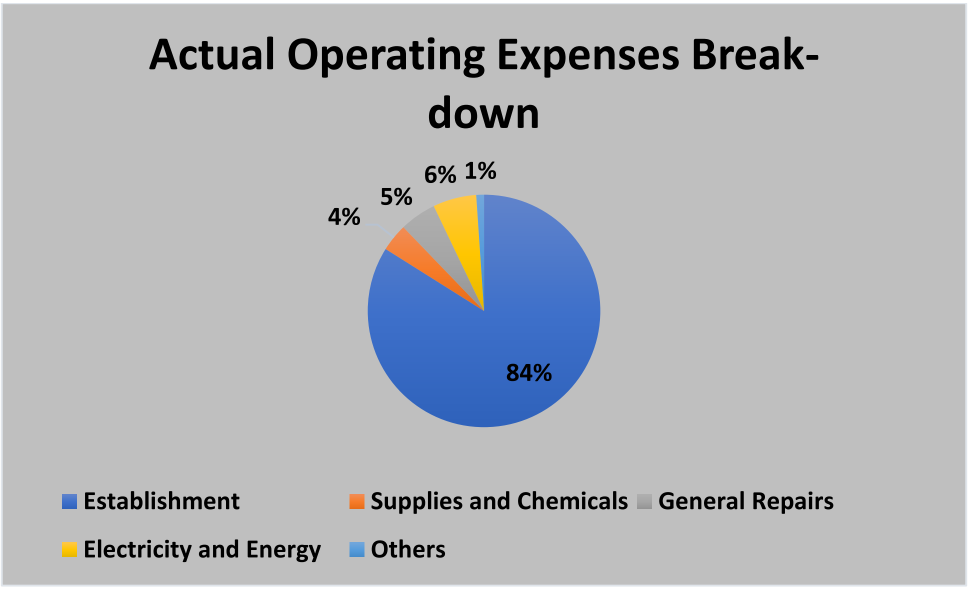
Particulars	2014-15		2015-16		2016-17
	Budget	**Actual**	**Budget**	**Actual (till Dec '15)**	**Budget**
Establishment	9,359.00	8,651.18	12,028.00	6,724.01	14,020.00
Supplies and Chemicals	833.00	397.94	873.00	363.29	980.00
General Repairs	990.00	524.16	1,040.00	559.63	1,325.00
Electricity and Energy	4,200.00	622.45	5,500.00	183.59	5,700.00
Others	278.00	110.65	319.00	83.67	340.00
Total Operating Expenses	**15,660.00**	**10,306.38**	**19,760.00**	**7,914.19**	**22,365.00**

Source: Lucknow Municipal Corporation

For the year 2014-15 being the latest year wherein the complete actual numbers were available, a look at the below pie chart shows that 60% of the total budgeted amount was kept for establishment expenses whereas 84% of the actual expenditure incurred was towards establishment. The actual expenditure on electricity and energy was only 6% of the total amount whereas the budgeted amount was 27% of the operating expenditure budget.

[8]All financial analysis is based on the budgetary report shared by LMC

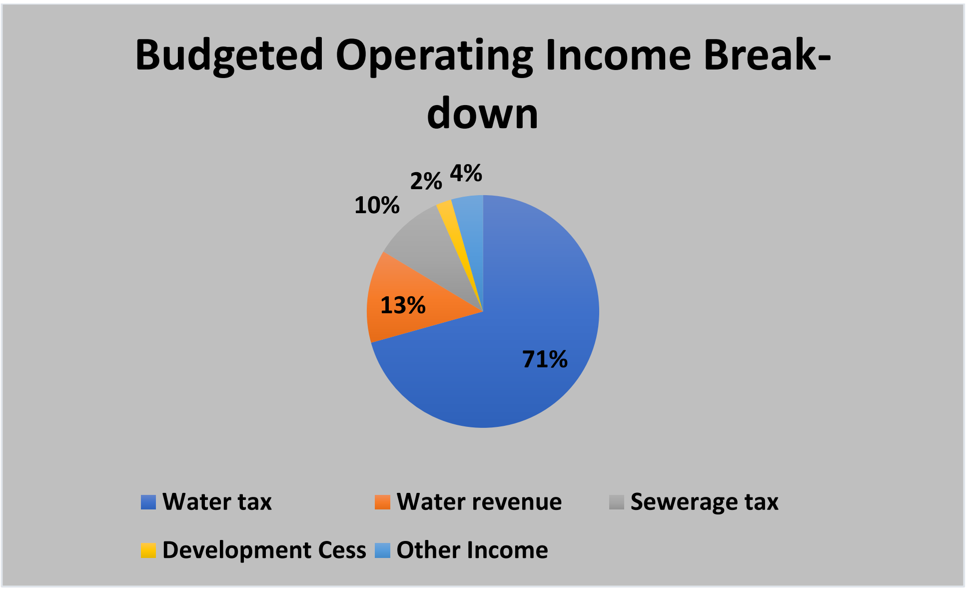


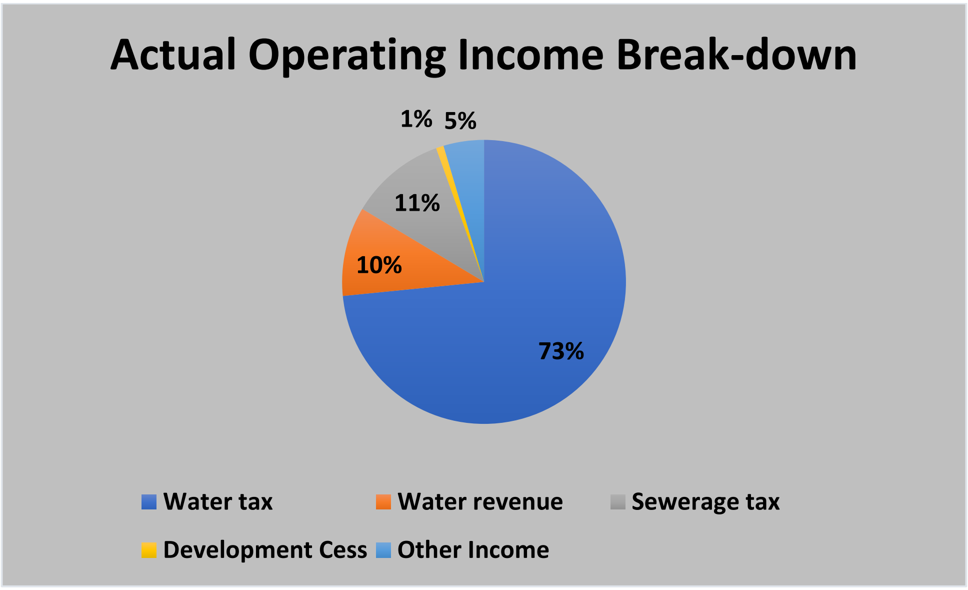


3.4.4 Sales and Recovery

3.4.4.1 Operating Income of Jal Kal Division

The income received by the Jal Kal division can be segregated in the manner mentioned below. The actual revenues have been very close to the projected revenues.





3.4.5 Overall Financial Analysis

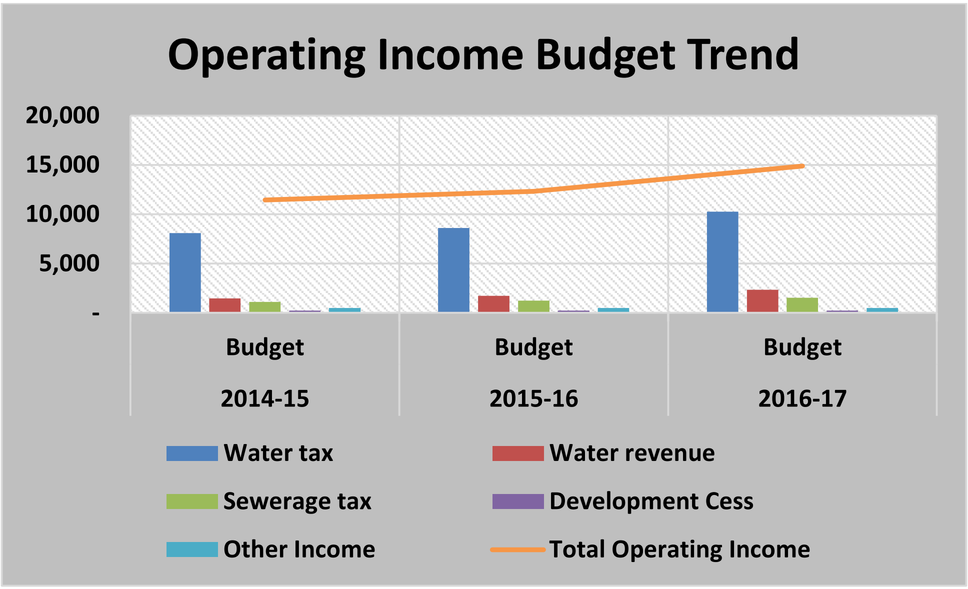
3.4.5.1 Jal Kal Division Cost Recovery

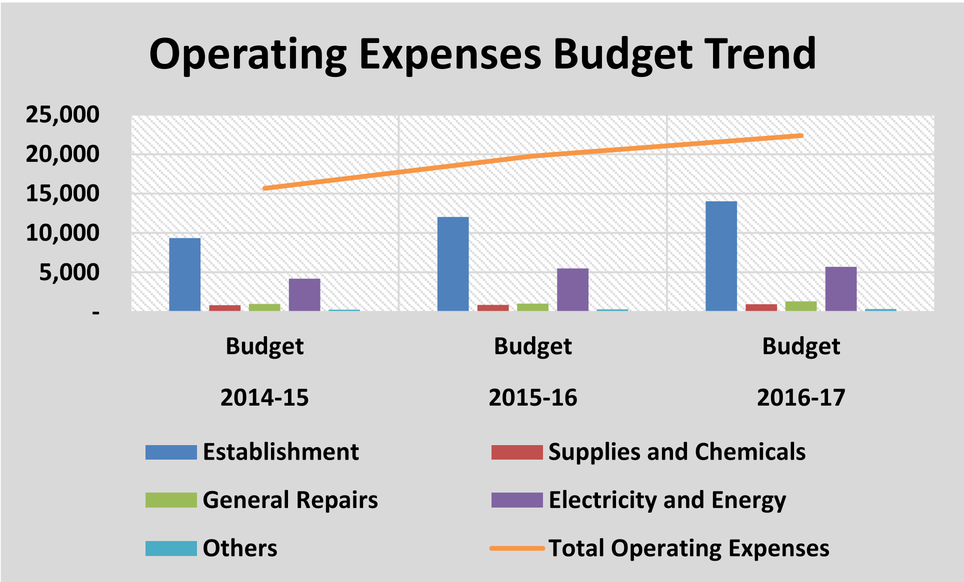
The Jal Kal division has been operating with cost recovery of 106% in 2014-15. The financials at the operation level and budget trends can be seen in the following table and charts respectively:

Table 19: Operational Surplus/ Deficit of Jal Kal Division

(Rs. in lakhs)					
Particulars	**2014-15**		**2015-16**		**2016-17**
	Budget	**Actual**	**Budget**	**Actual (till Dec '15)**	**Budget**
Income	11,445.00	10,974.11	12,321.00	7,262.96	14,884.00
O&M Expenses	15,660.00	10,306.38	19,760.00	7,914.19	22,365.00
Surplus/ Deficit	(4,215.00)	667.73	(7,439.00)	(651.23)	(7,481.00)

Source: Lucknow Municipal Corporation





3.4.6 Non-Operating Income & Expenses of Jal Kal Division

The analysis of the non-operating expenses and income shows the amount received under various grants and loans and interest paid on the loans. We found that Jal Kal received more funds than expected and loan and principal repayment has been budgeted but actual payment has not been made. The information has been summarized in the table below.

Table 20: Non-Operating Income of Jal Kal

(Rs. In lakhs)

Particulars	2014-15		2015-16		2016-17
	Budget	**Actual**	**Budget**	**Actual (till Dec '15)**	**Budget**
Return of earnest money	2.00	1.10	2.00	0.75	2.00
Earnest money for deposit	355.86	503.26	351.96	452.94	349.35

Fund-13th finance commission	-	1,639.13	1,000.00	1,776.25	-
Dal mandi sewerage loan	0.97	0.97	-	-	-
Grants	3.57	3.57	-	-	-
Revolving fund loan	5.28	5.28	5.28	5.28	-
Other receipts	85.73	44.74	85.25	19.22	84.92
Total	**453.41**	**2,198.05**	**1,444.49**	**2,254.44**	**436.27**

(Rs. in lakhs)

Non-Operating Expenses of Jal Kal Division

Particulars	**2014-15**		**2015-16**		**2016-17**
	Budget	**Actual**	**Budget**	**Actual (till Dec '15)**	**Budget**
Loan and Principal return	327.89	-	327.89	-	327.89
Deposit work	355.86	98.08	351.96	22.93	349.35
Interest on Loan-13th Finance commission	0.97	918.09	1,000.00	1,186.24	-
Interest sewer line	3.57	0.97	-	-	-
Grant	-	3.57	-	-	-
Loan revolving fund	5.28	-	5.28	-	-
Total	**693.57**	**1,020.71**	**1,685.13**	**1,209.17**	**677.24**

Source: Lucknow Municipal Corporation

Capital Expenditure of Jal Kal Division

We also looked at the capital expenses of the Jal Kal division and found that the actual expenditure is between 11%-16% of that budgeted. This excess amount can be used in the budget for some other expenses.

Table 21: Capex of Jal Kal Sansthan

(Rs. in lakhs)					
Capital Expenditure	**2014-15**		**2015-16**		**2016-17**
	Budget	**Actual**	**Budget**	**Actual (till Dec '15)**	**Budget**
Water meter	3.00	-	3.00	-	3.00
Hand pump automation	25.00	-	25.00	18.06	25.00
Water pipeline extension	50.00	6.13	60.00	17.45	70.00
Equipment and machinery	25.00	5.12	25.00	3.00	30.00
Furniture	10.00	-	10.00	0.16	10.00
Building construction	95.00	0.16	85.00	-	105.00
Hand pump/Stand post installation	75.00	-	75.00	-	80.00
New vehicle	15.00	-	10.00	-	10.00
Sewerage pipeline extension	75.00	11.97	55.00	15.11	60.00
New motor (water)	50.00	48.76	130.00	57.67	150.00
New motor (sewerage)	50.00	8.81	40.00	4.12	60.00
Tube well boring/boring/development	250.00	6.84	250.00	9.49	250.00
Others	72.00	3.04	97.00	20.62	107.00
Total Operating Expenses	**795.00**	**90.83**	**865.00**	**145.68**	**960.00**

Source: Lucknow Municipal Corporation

3.5 CUSTOMER METERING, BILLING AND COLLECTION

3.5.1 Metering

In Lucknow city, there are no consumer meters installed. There are very few bulk meters installed in the transmission and / or distribution line. The details of bulk meters installed are–

- Two electromagnetic meters are installed at the outlet of Balaganj 900mm dia. PSC
- Three meters are installed at the outlet of 80 MLD WTP with two being operational which needs accuracy check to be done
- One meter is installed at the outlet of 900mm pipe at Aishbagh WTP

3.5.2 Billing

The billing is done annually once to all the consumers by Jal Kal Sansthan. Typical copy of the bill is attached in the Annexures.

The Jal Kal department has specified following details relevant to bill payment procedures –

1. Payment if made within 30 days (i.e. between the bill date and due date) the utility will give discount of 10% on the bill amount to the payee
2. If the payment is made beyond due date and before the last date, then the actual bill amount is to be paid
3. If the payment is made beyond the last date, then additional 10% surcharge on the bill amount is added and to be paid
4. If the payment is still not done, then, the utility department will cut the connection
5. For properties with undetermined ARV, consumers with area below 13 sq. m. are charged minimum water bill of Rs. 588 and above 13 sq. m. the billed amount for water is Rs. 735. Similarly for properties with 20 mm pipe connection, minimum charges are Rs. 2205 and for 25 mm pipe connection, minimum charges are Rs. 2940
6. Sewer charges will be 3% of ARV or 3% of water charges whichever is higher

3.5.3 Collection

The collection data from the budgetary report covers information on total connections, past years' demand and current years' demand. Please find details for 2017-18 as tabulated below–

Zones	# of Connections	Arrears Demand (Rs.)	Present Demand (Rs.)	Total Demand (Rs.)
Zone 1	45032	9293,24,000	1923,73,000	11216,97,000
Zone 2	46625	3582,40,000	1181,82,000	4764,22,000
Zone 3	62908	4110,07,000	1254,03,000	5364,10,000
Zone 4	31461	-	-	-
Zone 5	-	-	-	-
Zone 6	-	-	-	-
Zone 7	32381	1500,00,000	76,39,700	1576,39,700
Zone 8	47740	3778,99,000	792,32,000	4571,31,000
Total	266147	22264,70,000	5228,29,700	27492,99,700

Source: Lucknow Municipal Corporation

Note: There is incomplete / no information for zones 4, 5 and 6 at present. It will be covered in subsequent reports

3.6 SERVICE LEVEL BENCHMARK

3.6.1 Water Supply Services

SN	Indicator	Units	SLB value	Lucknow Values (Ceinsys analysis)
1	Coverage of Water Supply Connections	%	100%	71%[15]
2	Per capita supply of water	LPCD	135	179[16]
3	Extent of metering of water connections	%	100%	0%
4	Extent of non-revenue water	%	20%	54.70%
5	Continuity of water supply	Hours per day	24x7	5 hours daily
6	Quality of water supplied	%	100%	LMC doesn't have enough data to compute this KPI
7	Cost recovery in water supply services	%	100%	104%*
8	Efficiency in redressal of water supply services	%	80%	LMC doesn't have mechanism in place for consumer Redressal and grievance
9	Efficiency in collection of water supply related charges	%	90%	LMC doesn't have recovery data

Source: Lucknow Municipal Corporation

3.7 TARIFF STRUCTURE AND COST RECOVERY

The tariff for consumers is as per ARV. Last the tariff was updated in the year 1996[17]. The charges as per categorization of slabs is below,

3.7.1 Tariff for Water Supply

Table 22: Tariff Structure

Annual Rental Value (ARV) (in absolute numbers)	Charges (in Rs. /month)		
	Pipe sizes (in mm)		
	15 mm	20 mm	25 mm
0 – 360	441	661.5	1029

[15] Coverage = Water pipeline length / Total Road length = 2748 / 3850 = 71.37% (AMRUT SLIP - Lucknow 2015)
[16] LPCD calculations were done taking readings from DMA inlet as interconnections and network map was not available to take input reading from Distribution network. This also include ground water as there is mixed supply in the entire city.
[1] Revised City Development Plan Lucknow City-2040 Volume- I
[17] CPHEEO Report on Water Supply (2005 report)

361 – 2000	588	682	1323
2001 – 3500	882	1323	2058
3501 – 5000	1176	1690.5	2499
5001 and above	1470	2205	2940
	Or 12.5 % of ARV, whichever is greater		

Source: Lucknow Municipal Corporation

3.7.2 Cost Recovery and Cost of Water

Table 23: Cost Recovery and Cost of Water

Operating Expenses of Jal Kal division	
Particulars	**2014-15**
	Actual (Rs. Lakhs)
Establishment	8,651.18
Supplies and Chemicals	397.94
General Repairs	524.16
Electricity and Energy	622.45
Others	110.65
Total Operating Expenses	10,306.38

Source: Lucknow Municipal Corporation

Non-Operating Expenses of Jal Kal division	
Particulars	**2014-15**
Loan and Principal return	-
Deposit work	98.08
Interest on Loan – 13th Finance Commission	918.09
Interest sewer line	0.97
Grant	3.57
Loan revolving fund	-
Total	1,020.71

Source: Lucknow Municipal Corporation

Capital Expenditure	2014-15
Water meter	-
Hand pump automation	-
Water pipeline extension	6.13

Equipment and machinery	5.12
Furniture	-
Building construction	0.16
Hand pump/Stab post installation	-
New vehicle	-
Sewerage pipeline extension	11.97
New motor (water)	48.76
New motor(sewerage)	8.81
Tube well boring/boring/development	6.84
Others	3.04
Total Capital Expenditure	90.83

Source: Lucknow Municipal Corporation

Operating Income details	
Particulars	**2014-15 (Rs. Lakhs)**
Water tax	8,057.23
Water revenue	1,116.84
Sewerage tax	1,198.67
Development Cess	95.10
Other Income	504.67
Total Operating Income	10,972.51

Source: Lucknow Municipal Corporation

*Since Sewer tax is around 10.92% of Total Operating Income, here water numbers are assumed to 89.1% of total. Water heads mentioned explicitly have been taken as it is.

Non-Operating Income of Jal Kal Division	2014-15 (Rs. Lakhs)
Return of earnest money	1.10
Earnest money for deposit	503.26
Fund-13th finance commission	1,639.13
Dal mandi sewerage loan	0.97
Grants	3.57
Revolving fund loan	5.28
Other receipts	44.74
Total	2,198.05

Source: Lucknow Municipal Corporation

Thus, Cost Recovery = $\frac{\textit{Total Annual Operating Revenue}}{\textit{Total Annual Operating Expenses}}$ x 100%

Cost of Water = $\frac{\textit{Total Annual Water Costs}(Rs.)}{\textit{Annual System Input Volume}(kilo-litre)}$

% share of water determined as per operating income	
Water	**89.1%**
Water Revenues	
Operating revenues (A)	9,708.47
Non-operating revenues	1,957.60
Total Water Revenues	11,666.06
Water Costs	
Operating expenses (B)	9,363.40
Non-operating expenses	908.59
CAPEX	70.05
Total Water Costs	10,342.04
Cost of Water (Rs./ kilo-litre)	3.55
Cost recovery of water division (A)/(B)	**103.69%**
System Input Volume (MLD)	797.37

Source: Lucknow Municipal Corporation

4 METHODOLOGY USED & WATER BALANCE

The "Authorized Consumption" is the volume of metered and/or un-metered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so by the water supplier, for domestic, commercial and industrial purposes. It includes water exported.

The authorized consumption includes items such as firefighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, building water. These may be billed or unbilled, metered or un-metered according to local practice.

4.1 IDENTIFICATION OF FLOW MEASUREMENT POINTS:

One of the key parameters of a water distribution system is the volume of water distributed. This enables assessing the level of non-revenue water at various stages and is important from the point of view of calculating various ratios.

a) Identification of flow measurement points:

The main objective of the activity was to identify all flow measurement points of the system and be in position to assess the volume of water supplied into the project area. Following methodology was adopted while implementing the activity –

- Identification of all pipes crossing the boundaries of the project area from the existing map of the system. Conduct field investigations and discussions with LMC staff
- Identification of the trunk mains crossing the project area without tapping points in the area
- Identification of the inlet pipes crossing the project area with an objective to limit the number of flow meters to be installed to assess input volume to the project area
- Identification and excavation of the best location to install flow meters considering traffic and technical constraints for flow measurement
- Assessment of flow input in the project area

As observed, the project area is being supplied by two sources i.e. Gomti River and Sharda Sahayak Canal.

b) Flow Measurement:

Clamp on type ultrasonic flow meters were installed at the inlet points to measure / compare the actual flow.

Ceinsys Tech has performed flow measurement activity at various inlet and outlet points of the project area to access the total system input volume in the project area and results for the same are mentioned in following sections.

4.1.1 Aishbagh WTP

Aishbagh water supply scheme is the largest water supply scheme in the city.

Figure 34: Flow Measurements of Water at Aishbag

4.1.1.1 Transmission Loss (Source to WTP)

Raw Water Transmission Loss

Gaughat RW Outlet			Aishbagh WTP Inlet		RWPM Losses (MLD)	RWPM Losses (%)
M No.	**Pipe Dia. (mm)**	**FLOW(MLD)**	**M No.**	**FLOW(MLD)**		
M-1	500	26	**M-2**	25.1	0.9	**3.46%**
M-3	675	40.95	**M-4**	39.76	1.19	**2.91%**
M-5	1300	92.28	**M-6**	89.29	2.99	**3.24%**
M-7	1200	81.54	**M-8**	34.45	2.09	**2.56%**
			M-9	45		
Total		**240.77**		**233.6**	**7.17**	**2.98%**

Source: Lucknow Municipal Corporation

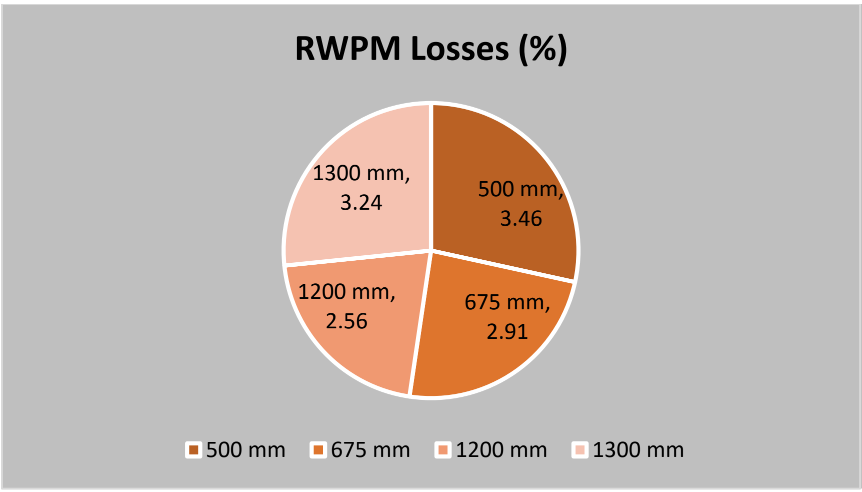


Figure 35: RWPM Losses of Aishbagh Water Supply Scheme

4.1.1.2 WTP Loss

Sequence and details of Aishbagh Water Supply Scheme with supply area or UGR age. Pipe dia. & distance and existing condition addressing to current losses.

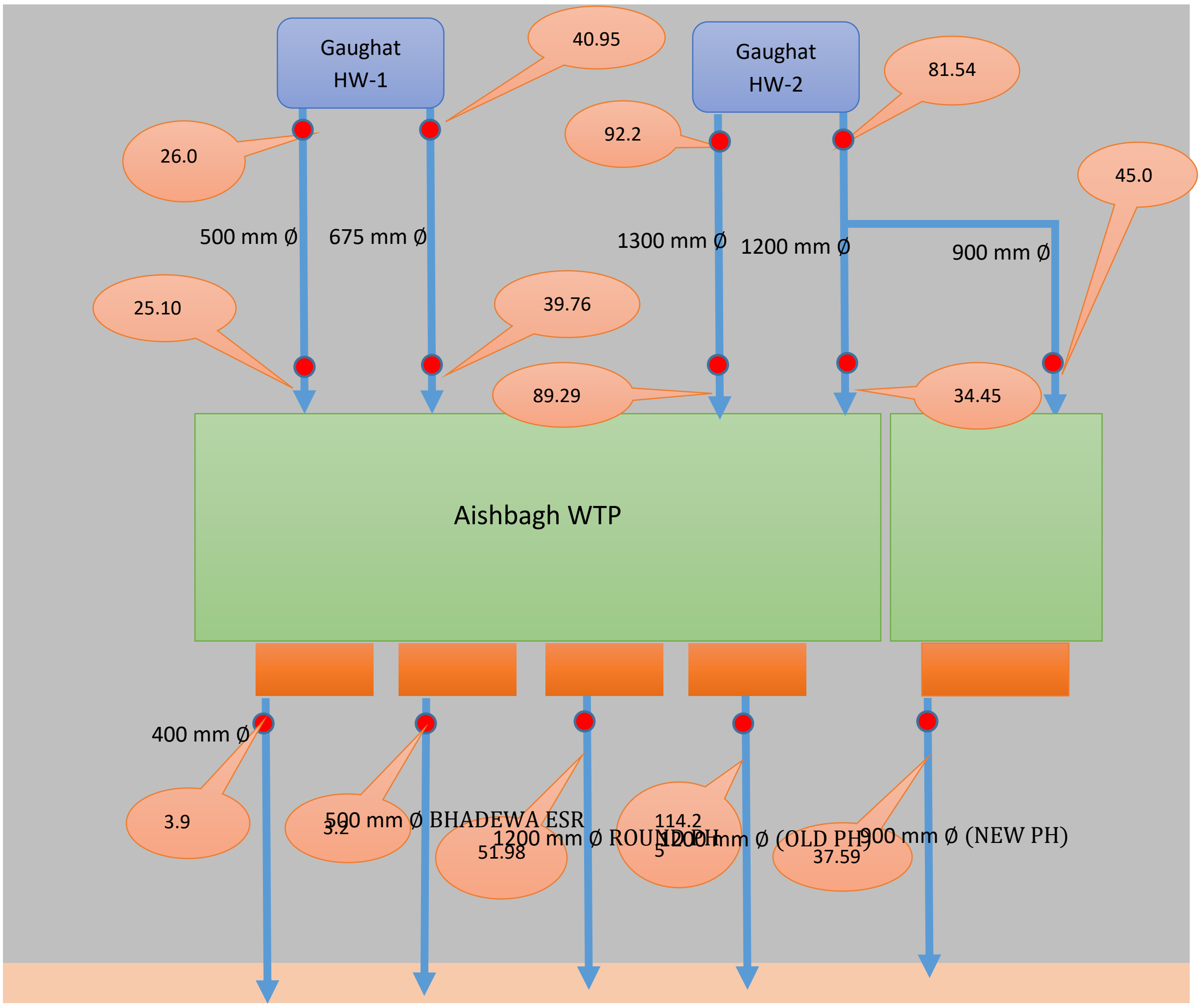


Figure 36:Sequence of Flow Measurement of Aishbagh Water Supply Scheme

Losses at Aishbagh WTP

Aishbagh WTP Inlet		Aishbagh WTP Outlet			WTP Losses (MLD)	WTP Losses (%)
M. No.	**Flow (MLD)**	**M. No.**	**Pipe Dia. (mm)**	**Flow (MLD)**		
M-2	233.60	**M-10**	SMALL PUMP HOUSE	3.90	22.68	9.71%
M-4		**M-11**	BHADWA PUMP HOUSE 500MM	3.20		
M-6		**M-12**	NEW ROUND PUMP HOUSE 1200	51.98		
M-8		**M-13**	OLD PUMP HOUSE s1200MM	114.25		

M-9		**M-14**	NEW JAL NIGAM PUMP HOUSE 900MM	37.59		
	233.60			**210.92**	**22.68**	**9.71%**

Source: Lucknow Municipal Corporation

Note: Quantum of backwash water 9.5 MLD is being recycled in Aishbagh WTP.

4.1.1.3 Total Losses

Aishbagh WTP receives raw water from Gaughat raw water through 2 pumping houses (named 1 and 2). Pump house 1 supplies raw water to the WTP through 2 pipes of 1300mm and 1200mm dia. whereas pump house 2 supplies through two pipes of 675mm & 500mm dia. from Gaughat RWPS to Aishbagh WTP. It was found that all the pipe lines are mostly aligned underneath the colonies, residential & commercial constructions and private properties. The approximate lengths of the transmission mains pipelines are as below for respective pipes –

- Pump House 1:
  - 1300mm dia. pipeline – 8.75 km,
  - 1200mm dia. pipeline – 4.85 km
- Pump House 2:
  - 675mm dia. pipe line – 5.17 km,
  - 500mm dia. Pipe line- 8.5 km

The control or isolation valves in the phase between Gaughat to Aishbagh are hardly noticeable; also, interconnections are not documented or visible at all in most cases. The higher dia. pipelines are mostly cross connected over the large open sewer drains of the city.

All four inlets meet in a RECTANGULAR WIRED SHARP CRESTED CONTRACTED structure having facility of measuring the total inlet water by Parshall Flume method but the system is not in good condition due to lack of proper maintenance, and hence, the measurement can only be taken manually.

There is a 900mm dia. tapping from 1200mm dia. transmission pipe line at the inlet of Aishbagh which is for Bird Filter plant having capacity of 45 MLD which is one out of the four filter plants in Aishbagh WTP – Patterson Filter plant no. 1, Patterson Filter plant no. 2, Candy filter plant and Bird Filter plant.

The total quantum of backwash water which is 9.5 MLD, is being recycled back to the Aisgbagh inlet in Aishbagh water treatment plant. And this amount is already considered in the outlet of WTP.

There are 5 pump houses in Aishbagh water treatment plant out of which one is fully dedicated to Bhadwa ESR which is used to distribute water for government quarters in side works premises and a small pocket of city supply. And other pumping stations are for separate Zonal Pumping Stations in the distribution system of Lucknow city.

Lucknow Municipal Corporation does not have any data that can define alignment of the transmission or distribution network. As a result, lot of trial pits, joint site visits and analysis procedure to find out pipeline both inside and outside works premises with proper location was undertaken considering all the limitations of Ultrasonic Flow Meter. These set of activities took lot of time in execution extending the project timelines to a non-desirable limit.

4.1.2 Balaganj WTP

Balaganj WTP is the second biggest water treatment plant in city Lucknow water supply system. There exist 2 filter plants in this WTP – commonly referred to as old and new.

Figure 37: Balaganj WTP Flow Measurement

Figure 38: Leakages of Balaganj WTP

Figure 39: Flow Measurement

Figure 40: Settling Tank

Figure 41: Flow Measurement

4.1.2.1 Transmission Loss (Source to WTP)

Raw Water Transmission Losses

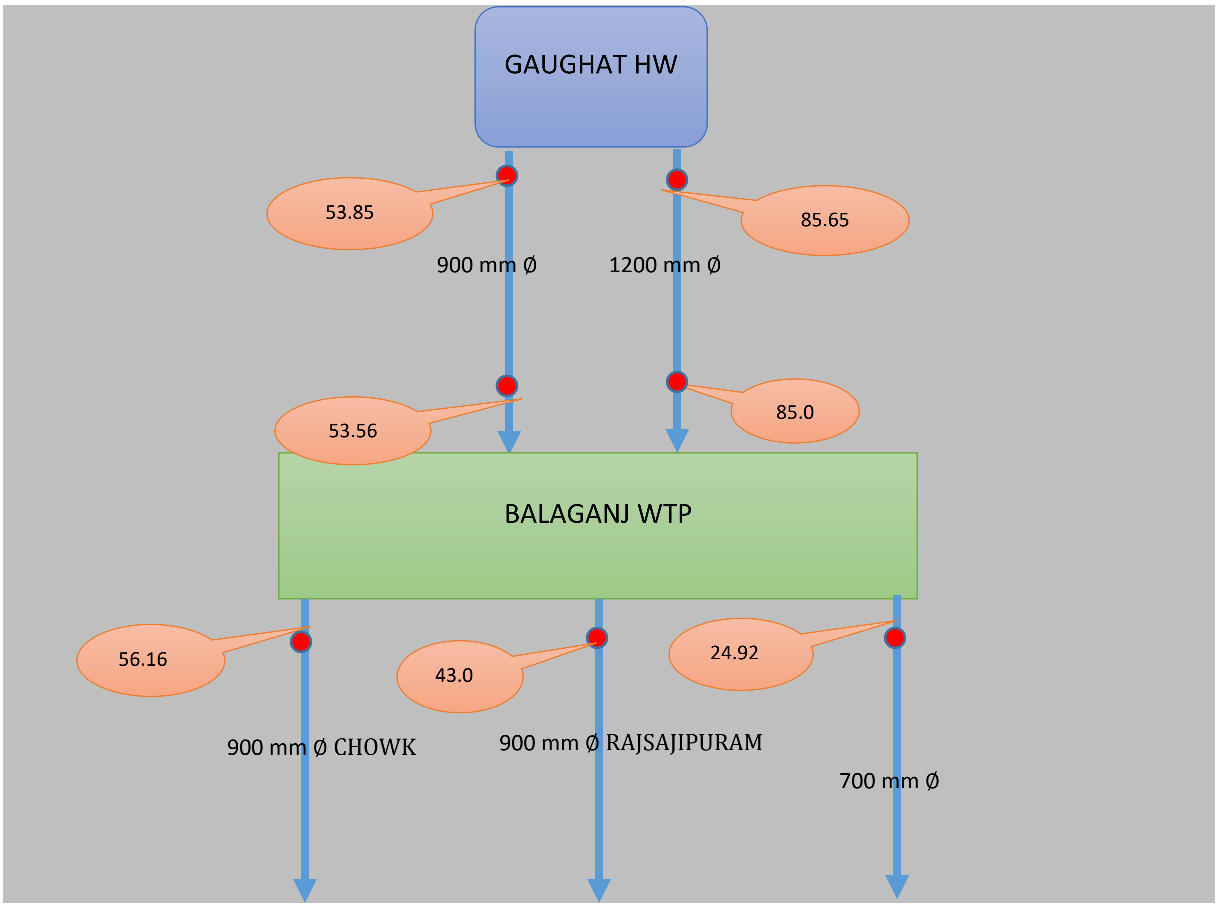
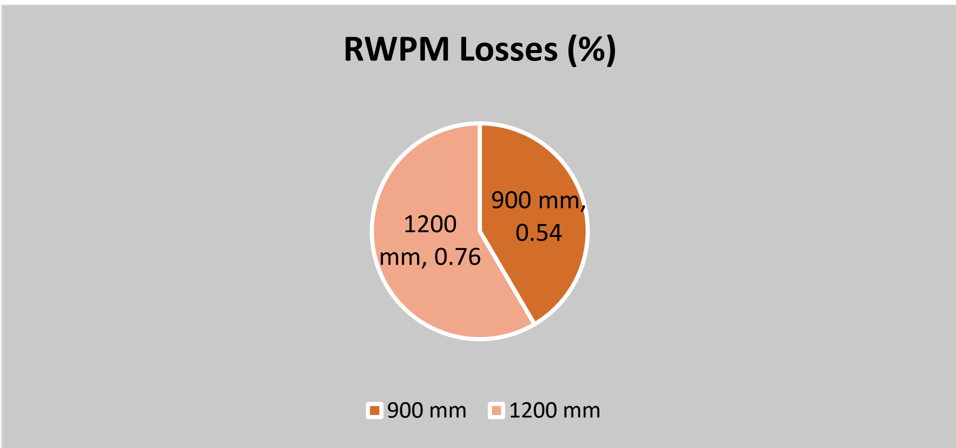


Figure 42: Sequence of Flow Measurement of Balaganj Water Supply Scheme

Gaughat RW Outlet			WTP Inlet	RWPM Losses (MLD)	RWPM Losses (%)
M No.	Pipe Dia. (mm)	FLOW(MLD)	FLOW(MLD)		
M-1	900	53.85	53.56	0.29	0.54%
M-2	1200	85.65	85.0	0.65	0.76%
Total		139.5	138.56	0.94	0.67%

Source: Lucknow Municipal Corporation



4.1.2.2 WTP Loss of Balaganj WTP

Losses at Balaganj WTP:

Balaganj WTP Inlet		Balaganj WTP Outlet			WTP Losses (MLD)	WTP Losses (%)
M. No.	**Flow (MLD)**	**M. No.**	**Pipe Dia. (mm)**	**Flow (MLD)**		
M-15	138.56	**M-19**	CHOWK 900MM	56.16	14.48	10.45%
M-17		**M-20**	RAJAJIPURAM 900MM	43.00		
		M-21	700MM	24.92		
	138.56			**124.08**	**14.48**	**10.45%**

Source: Lucknow Municipal Corporation

Note: Total quantum of backwash water of 3.8 MLD is not being recycled and considered as loss.

4.1.2.3 Total Losses of Balaganj

Balaganj WTP receives raw water from Gaughat raw water pumping station through two dedicated inlet transmission pipelines of 1200mm dia. supplying raw water to old filter plant and 900 mm dia. supplying to new filter plant.

The approximate length of the inlet transmission pipe lines is –

- 1200 mm dia. pipe line – 1.64 km
- 900 mm dia. pipe line – 1.58 km

There exist two major leakages and few other minor leakages in the water works which drains the water out round the clock. There are leakages in the inlet 900mm dia. pipeline in air valve and in the settling tank of the filter plant.

Within this WTP, the new filter plant gets water for backwash purpose from the ESR within the premises with the old plant having its own back washing facility of 0.5 MLD quantity of water.

4.1.3 Gomti Nagar Water Supply System WTP (80 MLD)

Figure 43: Pumping Machinery

Figure 44: WTP

Figure 45: Flow Measurement

Figure 46: Flow Measurement

4.1.3.1 Transmission Loss (Source to WTP)

This WTP receives raw water from Sharda Sahayak Canal, there is an artificial lake adjacent to the plant at negligible distance from the plant. There are hardly any chances of losses getting monitored in this case. Hence, no flow measurement is required at this stage.

4.1.3.2 WTP Loss

Losses at 80 MLD WTP

80 MLD WTP Inlet			80 MLD WTP Outlet			WTP Losses (MLD)	WTP Losses (%)
M. No.	**Pipe Dia. (mm)**	**Flow (MLD)**	**M. No.**	**Location**	**Flow (MLD)**		
M-22	1000	87.58	M-23	Outlet 800 Gomti Nagar	42.78	1.49	**1.70%**
			M-24	Outlet 800 IndraNagar	41.54		
			M-25	Outlet 250 Vastu Khand	1.77		
Total		**87.58**			**86.09**	**1.49**	**1.70%**

Source: Lucknow Municipal Corporation

Note: 2.3 MLD backwash is being recycled and reused.

4.1.3.3 Total Losses

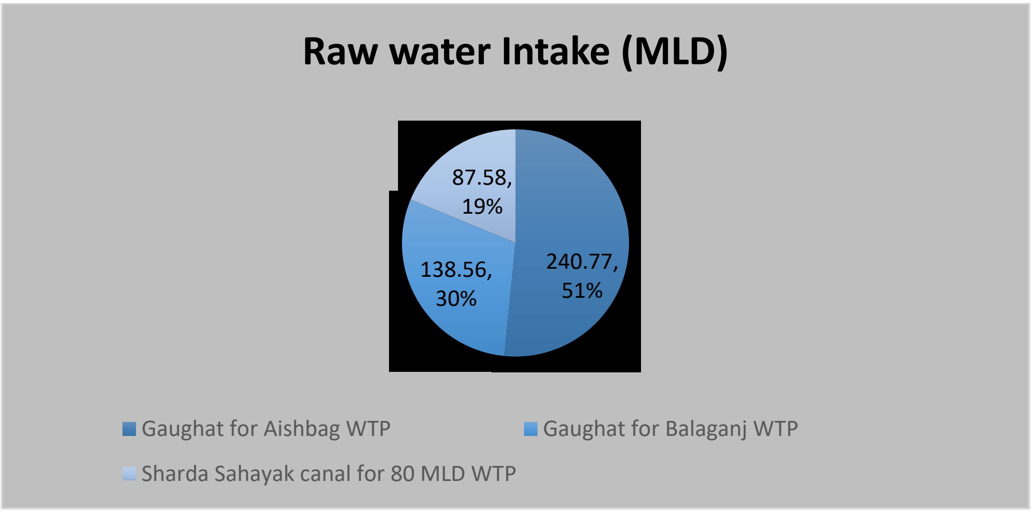
Since there the only loss to be accounted in this case is of within WTP, hence it is same as the losses at WTP which is 1.70%

4.1.4 Current Water Balance up to WTP outlet

System Input Volume

S. N.	Source	Raw water Intake (MLD)
1	Gaughat for Aishbag WTP	240.77
2	Gaughat for Balaganj WTP	138.56
3	Sharda Sahayak canal for 80 MLD WTP	87.58
	Total (MLD)	**466.91**

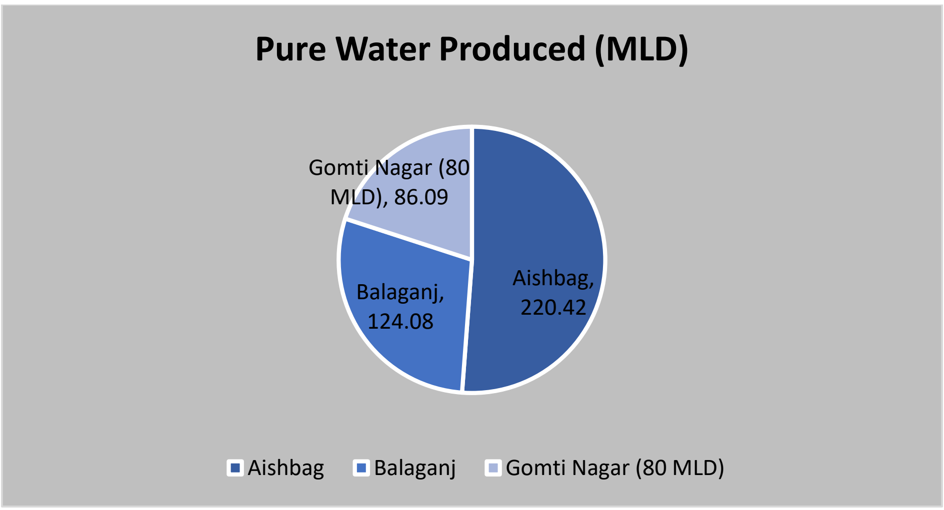
Source: Lucknow Municipal Corporation



Production of Pure Water

Sr. No.	WTP	Pure Water Produced (MLD)
1	Aishbag	220.42
2	Balaganj	124.08
3	Gomti Nagar (80 MLD)	86.09
	Total (MLD)	**430.59**

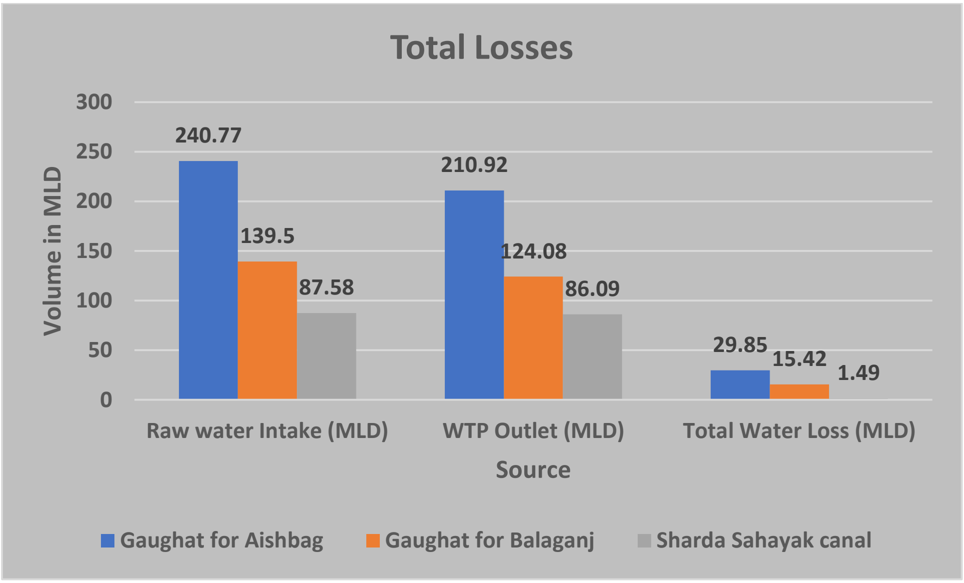
Source: Lucknow Municipal Corporation



Total water Losses

S.N.	Source	Raw water Intake (MLD)	WTP Outlet (MLD)	Total Water Loss (MLD)	Total Water Loss (%)
1	Gaughat for Aishbag	240.77	210.92	29.85	12.4%
2	Gaughat for Balaganj	139.50	124.08	15.42	11.05%
3	Sharda Sahayak canal	87.58	86.09	1.49	1.70%
Total (MLD)		**467.85**	**421.09**	**46.76**	**9.99%**

Source: Lucknow Municipal Corporation



4.1.5 Transmission

Transmission pipe line details from raw water to WTP inlet are tabulated below,

Table 24: Raw Water Transmission Pipeline Details[18]

WTP	RW Transmission Pipeline Material	RW Transmission Pipeline Length (kms)	RW Transmission Pipeline Diameter (mm)
AishBagh WTP	MS	12	1300
	PSC	14	1200
	MS	11	675
	MS	14	500
Balaganj WTP	MS	1.5	1200
	MS	1.5	900
80 MLD WTP	MS	7	1300
Total length up-to WTP		**61**	

Source: Lucknow Municipal Corporation

[18] Ceinsys team in consultation with Jal Kal, Lucknow

4.2 IDENTIFICATION OF DMA

The establishment of DMAs involves sub-division of network into DMAs supplied by a limited number of key mains on which flow meters are installed. DMA approach is incorporated to a specific area typically to gauge details on a sample area with certain qualifying criteria. Each DMA is a hydraulically separate portion of the network. It gives an iterative simulation process duly capturing the flow and pressure data of the current network scenario. This calibration helps in identifying anomalies and designing methods to optimize the network for correct pipe sizes and avoiding consumer complaints on irregular / inefficient water supply.

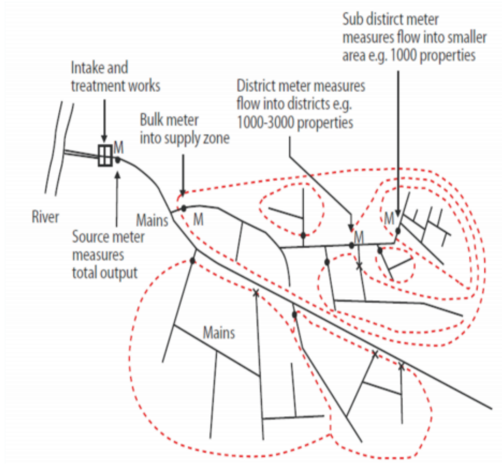


Figure 47: Sample DMA boundary

Following are the key criteria for DMA selection:

- Size of the area: Geographical area and number of connections
- Hydraulically isolated: The area should have the infrastructure to isolate hydraulically to calculate volume of water lost
- Consumer Category: A DMA should consist of consumers from all categories
- Variation in ground level: Area with high variation in ground level should be omitted. Flatter the area, more stable the pressures, the easier it is to establish pressure controls
- Pressure requirements: Need to ensure that pressure requirement is fulfilled
- Firefighting capacity: Area should have firefighting capacity if it is selected as DMA
- Number of valves to be closed: The number of valves to be closed to isolate the DMA should be minimum
- Number of meters: Minimum meters be required to measure inflows and outflows to increase the accuracy of measurements
- Service to the customer: Selecting the DMA should not affect the service to the consumers
- Minimum 5% of the proposed DMA & No of Connections.

Studying above criteria and in consultation with LMC, following 11 DMAs have been identified for Lucknow city:

Table 25: Identified DMAs in Lucknow

SN	Name	Status	Comments
1	Indra Nagar Sector 19	Sanctioned	Indra Nagar has the infrastructure to isolate itself hydraulically. Indra Nagar contains combination of consumers of all category
2	Gomti Nagar Vishal Khand -1,2,3,4 & Digdiga village	Sanctioned	As per joint visit, analysis and consultation with LMC, the stated DMA was suited well to carry out NRW reduction survey
3	Rajajipuram – Sector A, B, C, D	Sanctioned	As per consultation with LMC the stated DMA were best to carry out NRW reduction survey
4	Jiya Mau	Sanctioned	As per consultation with LMC the stated DMA were best to carry out NRW reduction survey
5	Vastu Khand	Sanctioned	As per consultation with LMC the stated DMA were best to carry out NRW reduction survey
6	Ruchi Khand	Sanctioned	As per consultation with LMC the stated DMA were best to carry out NRW reduction survey
7	Ratan Khand	Sanctioned	As per consultation with LMC the stated DMA were best to carry out NRW reduction survey

8	Vikram Khand	Sanctioned	As per consultation with LMC the stated DMA were best to carry out NRW reduction survey
9	Eldico Udyan	Sanctioned	As per consultation with LMC the stated DMA were best to carry out NRW reduction survey
10	Ashiyana Sec. G1 & D	Sanctioned	As per consultation with LMC the stated DMA were best to carry out NRW reduction survey
11	Aliganj	Sanctioned	As per consultation with LMC the stated DMA were best to carry out NRW reduction survey

Source: Lucknow Municipal Corporation

DMA no.	DMA name	Zone #	Population	Total no. of properties	No. of DMA bulk meters at inlet
1	Indranagar	7	6583	1370	3
2	Gomti Nagar	4	7862	1605	7
3	Rajajipuram	6	7483	1747	7
4	Jiya Mau	1	4965	814	3
5	Vastu Khand	4	8630	1569	4
6	Ruchi Khand	8	16850	3370	5
7	Ratan Khand	8	2275	474	3
8	Viram Khand	4	8755	1751	3
9	Eldeco Udyan	8	7660	1532	4
10	Ashiyana Sec. G1 & D	8	37295	7459	9
11	Aliganj	3	7236	1206	2
	Total		**117276**	**22897**	**50**

Source: Lucknow Municipal Corporation

4.2.1 DMA Establishment

Once the 11 DMAs have been identified, following checks and activities will be performed to conduct flow measurement and analyse sample network areas.

As per the standards, once the DMAs are identified, the team should work for DMA preparation including isolation of the study area and fixing entry and exit points.

As per the standard methodology, it is required to install meters to calculate average usage of water in study area. But, due to resistance and opposition from the consumers, no meter installation could be done. After discussing the issue with LMC officials, it was decided to conduct volumetric measurement and based on that, we can analyse the DMA properties. Thus, volumetric readings will be taken for all 11 DMAs.

4.2.2 Consumer Side Measurements:

The team will setup records and its procedures, monitoring and data collection procedures. We will use the billing record to distribute the consumers in 4 categories:

- Domestic
- Non-Domestic
- Bulk
- Institutional/Government Offices

To establish background leakage in DMA the data of length of mains, number of property connections, average length of private connection pipe and how customer are connected to the distribution system etc. will be noted and studied.

Calculating LPCD:

Volumetric Measurements will give result of average LPCD and consumption per household for all 11 DMAs. This number will then be extrapolated to total population of the city. After calculating LPCD rate it will be extrapolated to city level by averaging out the LPCD rates of all considered DMAs. The average LPCD will then be multiplied by the population to measure the total consumption. Non-domestic, Bulk and Government/Institution consumers will be extrapolated. This will give total consumption of water for the Lucknow city.

4.2.3 Complaint Record Study and Maintenance:

Collect and study repair and maintenance data; also maintain and analyse complaints record. Further, as part of consumer survey, cover questions on complaints logged by consumers and their disposition towards response time and registering complaints. There will be continuous monitoring of customer complaints and special importance will be given to complaints pertaining to discoloration, low pressure and no water.

4.2.4 Primary Survey of Consumers:

The surveyors will interview the households and enquire about the number of people living within each property.

4.2.5 Metering at the Entry Point:

UFM will be installed at the entry point of the DMA. This will measure the total flow of water for the DMA. This measurement will be done for the same number of days as DMA study period to get the average flow measurement for all considered DMAs.

Difference between inflow through DMA and consumption by consumers of the DMA will give total loss for that DMA accounting to the physical loss in the DMA.

Leakage in DMA is the difference between inflow and outflow. In continuous network supply, leakages will be quantified at the time on minimum consumption, which usually occurs at night. As night consumption is usually very small, most of the flow would be due to leakages, pointing to direct measurement. Then, field monitoring will be undertaken to determine the average consumption. Minimum night flow will be the minimum of the aggregation of several meters. The night flow will be averaged out over a period. (Widely used is the period of 1 hour). Leakage estimates based on night flow measurement will be multiplied by NDF (Night Day Factor) to consider effect of pressure.

Extrapolation of key parameters for missing data points will be done based on best and worst case of the sample data. In networks subjected to intermittent supply, monitoring of a representative sample will be undertaken so that correct demand supply can be applied to the leakage calculation. In most cases, intermittent or low-pressure problems are usually caused by very high leakage in the network.

4.2.6 NRW Loss Computations:

Having extrapolated consumption to the city level we will have total water consumed at the user end. Also, total source water is known, so the difference will give account of total physical losses between demand and supply side.

DMA entry point reading and total consumption estimated within the DMA; the difference between these two will give physical losses at the DMA level.

4.2.7 Volumetric Measurements by calibrated measuring vessel & Digital meter method

Volumetric measurements have carried out for measuring the consumption of consumers, this method was adopted due to consumers not allowed to install consumer meters along service connections. This measurement will be done by calibrated measuring vessel testing method. Here, we will use calibrated bucket of capacity of 6 litres. Time required to fill this bucket will be noted and further analysis will be done. Also the temporary digital ultrasonic/multi-jet Consumer meters were installed at sample connections. there were taken volumetric readings by digital ultrasonic meter and multi-jet meter. Temporary bulk meters were installed at entry point of the selected DMA. Water supplied to the sub DMA and water consumed by the consumer in that sub DMA was quantified on top priority as these are important quantities of the water audit. Based on above activity we have installed digital ultrasonic/ multi-jet consumer water meters in DMA's and taken readings for the mentioned time duration on daily basis.

Few key points

- The app used for consumer survey has GIS tagging, it will be correlated to the volumetric data
- The activity will be done for 10% of the total consumers comprising of all categories
- Pressure measurements will also be taken at different points of the DMA using pressure gauge
- The bucket testing activity will be conducted in parallel for all 11 DMAs

4.2.8 Consumer Survey details



Figure 48: Consumer Survey Photos

Consumer survey will be conducted to gauge the supply side parameters from end users' perspective. Survey to understand interruptions, continuation, connection, billing, etc. will be conducted. Also, *Willingness to Pay* will be studied and analysed from consumer's behaviour point of view for any revisions foreseen in near future.

The requisite data will be collected through the survey methodology. Above mentioned survey will be conducted within the selected DMA boundary limits. The authorized personnel will collect the data through a mobile application present with them. The main points covered in the survey will be address of the consumer, size of the connection that the consumer is using, whether the bill is being supplied to the consumer or not, category of the consumer, etc.

The mobile application will be geographic information system enabled which will help to track the properties surveyed. The survey will also find out through which type of source, water is being currently supplied to the DMA – ground or surface water. We will focus on customers coming under the domestic category. The personnel authorized to undertake the survey will have to be authorized by LMC as well. Once done, they will be issued a proper id card.

The survey will cover information on general details like zone / ESR command area name, name and area of the locality, DMA number to trace back the consumer to a particular DMA, sub-DMA number, name of the surveyor, supply period in the morning, supply period in the evening, supply data gaps, number of properties in DMA, total number of connections, number of domestic connections, number of commercial consumers, number of institutional consumers, number of industrial consumers, number of unregistered consumers. This app is developed to increase the accuracy of results and minimize human intervention.

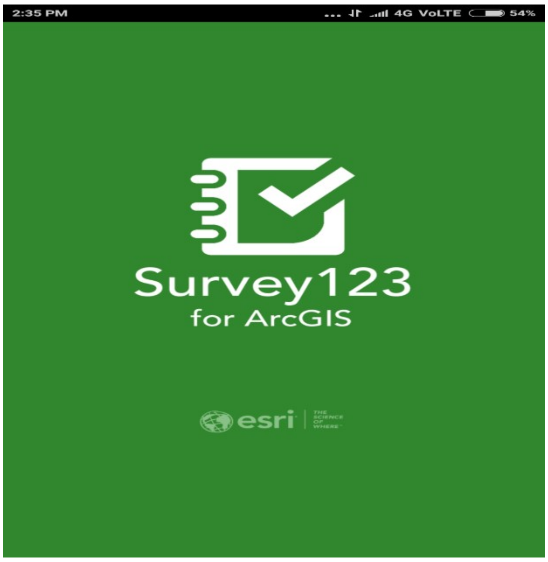


Figure 49: NRW Consumer Survey Application

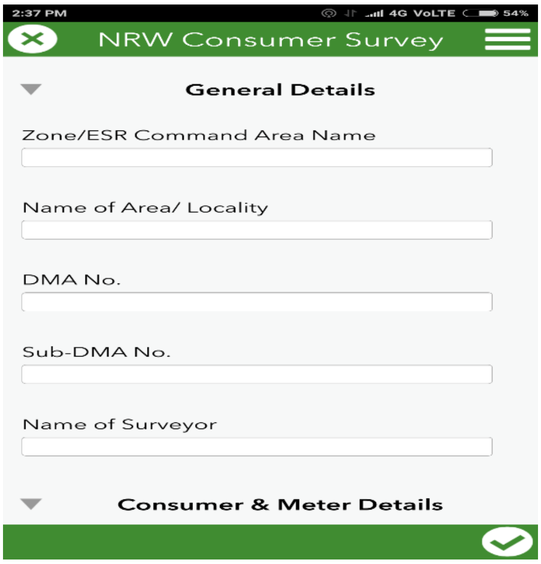


Figure 50: NRW Consumer Survey Application

NRW Projects Volumetric and Pressure will consist of details related to volume and pressure of the water at consumers' premises. The details collected will include Consumer house number/GIS plot ID, name of consumer, plot number, consumer number, type of connection, date and time of survey to maintain credibility of the data. Along with above mentioned data, flow of water will also be measured along with pressure. Photograph is mandatory to build reliability in the process of data collection.

The application has a feature by which the surveyor has the option to send the recorded data at the time of recording or he can save the details at that time and send all details at later point of time. This will help the surveyor to continuously carry on with the data collection without wasting any time for synchronizing with the cloud based database.

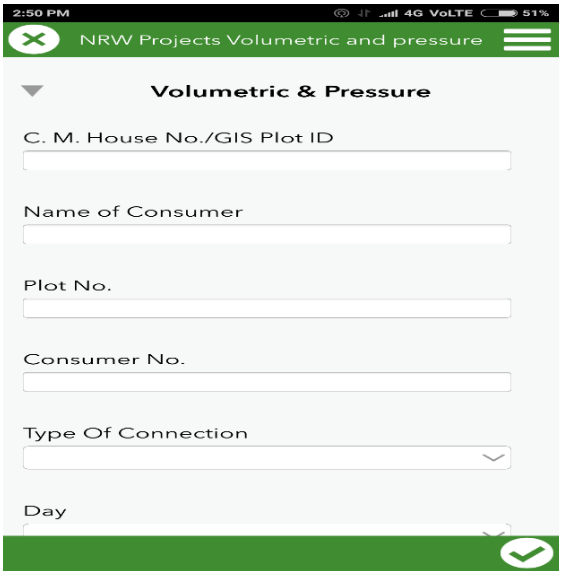


Figure 51 NRW Measure Volumetric & Pressure

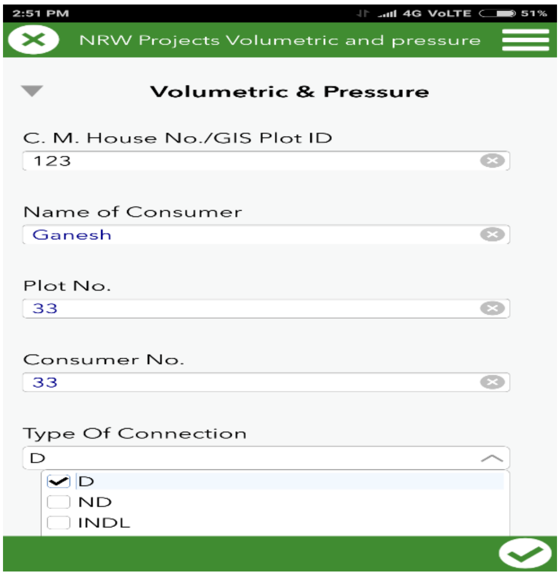


Figure 52: NRW Measure Volumetric & Pressure

4.2.9 Flow Measurements

Identification and Metering at the Entry Point of DMA:

Temporary meter was installed at the entry point of DMA to measure the total inflow of water for the DMA. This measurement was done for the same number of days as DMA study period to get the average flow measurement for all considered DMAs.

4.2.9.1 DMA-1 Indra Nagar

At the time of DMA isolation, it was observed that there were 3 sources of supply water for DMA-1 Indra nagar i.e. Tube well No. 40, 42 and supply from ZPS through Kathauta ESR. The readings from meters installed at inlet are tabulated below,

Input Volume in Indra Nagar Sector-19 DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	20	8	17.57	0.14
Tubewell 2	20	8	26.24	0.21
Tubewell 3	Non Functional			
(A) Total Input Under Ground Supply				0.35
(B) ESR Supply to DMA		3	55.35	0.17
Total Input Volume to DMA (A+B)				0.52

4.2.9.2 Gomti Nagar

At Gomti Nagar DMA, sources of water supply were 3 tub wells and 80 MLD WTP through ESR. The readings from meters installed at inlet are tabulated below,

Input Volume in Gomti Nagar DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	20	0.6	29.09	0.017
Tubewell 2	20	0.6	25.08	0.015
Tubewell 3	20	0.6	19.36	0.012
(A) Total Input Under Ground Supply				0.044
(B) ESR Supply to DMA		0.5	317.98	0.159
(C)Tubewell + ESR Supply to DMA		0.5	391.504	0.196
(D)Tubewell + ESR + 80 MLD Supply to DMA		4	635.96	2.544
(E)Tubewell + 80 MLD Supply to DMA		2	317.98	0.636
Total Input Volume to DMA (A+B+C+D+E)				3.579

4.2.9.3 DMA-3 Rajajipuram

At Rajajipuram DMA, sources for water supply were 5 tube wells and 1 ZPS through ESR. The readings from meters installed at inlet are tabulated below,

Input Volume in Rajaji Puram DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	20	22	23.55	0.52
Tubewell 2	20	16	16.68	0.27
Tubewell 3	20	16	16.99	0.27
Tubewell 4	20	16	19.05	0.30
Tubewell 5	20	16	29.71	0.48
(A) Total Input Under Ground Supply				1.84
B) Rajajipuram ZPS Direct Supply to DMA		1	130.17	0.13
(C) ESR Supply to DMA		2	22.88	0.05
Total Input Volume to DMA (A+B+C)				2.01

4.2.9.4 DMA-4 Jiya Mau

At Jiya Mau DMA, sources for water supply were 3 tube wells through ESR. The readings from meters installed at inlet are tabulated below,

Input Volume in Jiya Mau DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	20	16	26.21	0.42
Tubewell 2	20	16	27.10	0.43
Tubewell 3	20	16	26.69	0.43
Total Input Volume to DMA				1.28

4.2.9.5 DMA-5 Vastu Khand

At the time of DMA isolation, it was observed that there were 2 sources of supply water for DMA-5 Vastu Khand i.e. 3 no's of Tube wells and supply through ESR to distribution. The readings from meters installed at inlet are tabulated below,

Input Volume in Vastu Khand DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	20	8	44.18	0.353
Tubewell 2	25	8	55.21	0.442
Tubewell 3	15	8	27.16	0.217
(A) Total Input Under Ground Supply				1.012
(B) Surface Water Supply to DMA		7	149.68	1.048
Total Input Volume to DMA (A+B)				2.060

4.2.9.6 DMA-6 Ruchi Khand 1 & 2

At Ruchi Khand 1 & 2 DMA, sources for water supply were 5 tube wells through ESR. The readings from meters installed at inlet are tabulated below,

Input Volume in Ruchi Khand 1 & 2 DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	20	18	50.42	0.91
Tubewell 2	20	18	47.26	0.85
Tubewell 3	20	18	49.41	0.89
Tubewell 4	20	10	48.23	0.48
Tubewell 5	30	10	61.15	0.61
Total Input Volume to DMA				3.74

4.2.9.7 DMA-7 Ratan Khand

At Ratan Khand DMA, sources for water supply were 3 tube wells to direct distribution. The readings from meters installed at inlet are tabulated below,

Input Volume in Ratan Khand DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	25	5	52.46	0.26
Tubewell 2	25	5	51.84	0.26
Tubewell 3	25	5	51.73	0.26
Total Input Volume to DMA				0.78

4.2.9.8 DMA-8 Viram Khand

At the time of DMA isolation, it was observed that there were 2 sources of supply water for DMA-8 Viram Khand i.e. 2 no's of Tube wells and supply through ESR to distribution. The readings from meters installed at inlet are tabulated below,

Input Volume in Viram Khand DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	20	8	50.88	0.407
Tubewell 2	20	8	51.27	0.410
(A)Total Input Under Ground Supply				0.817
(B) Surface Water Supply to DMA		5.5	278.7	1.533
Total Input Volume to DMA (A+B)				2.350

4.2.9.9 DMA-9 Eldico Udyan

At Eldico Udyan DMA, sources for water supply were 4 tube wells through ESR. The readings from meters installed at inlet are tabulated below,

Input Volume in Eldico Udyan DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	15	18	26.41	0.48
Tubewell 2	15	8	25.28	0.20
Tubewell 3	20	8	40.14	0.32
Tubewell 4	15	18	26.22	0.47
Total Input Volume to DMA				1.47

4.2.9.10 DMA-10 Aliganj Sector-B

At Aliganj Sector-B DMA, sources for water supply were 2 tube wells through ESR. The readings from meters installed at inlet are tabulated below,

Input Volume in Aliganj Sec-B DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	25	18	51.51	0.93
Tubewell 2	25	18	52.37	0.94
Total Input Volume to DMA				1.87

4.2.9.11 DMA-11 Ashiyana Sec G &1D

At Aliganj Sector-B DMA, sources for water supply were 9 tube wells through ESR. The readings from meters installed at inlet are tabulated below,

Input Volume in Ashiyana Sec-G & 1D DMA				
Tubewell Supply to DMA				
Under Ground Supply	Capacity (HP)	Supply hrs.	Avg. Flow (M^3/hr)	Total Flow (MLD)
Tubewell 1	25	8	81.64	0.65
Tubewell 2	25	18	80.87	1.46
Tubewell 3	25	18	82.71	1.49
Tubewell 4	25	18	81.46	1.47
Tubewell 5	20	8	66.65	0.53
Tubewell 6	20	18	67.98	1.22
Tubewell 7	15	8	54.88	0.44
Tubewell 8	7.5	8	40.67	0.33
Tubewell 9	10	8	49.39	0.40
Total Input Volume to DMA				7.98

4.2.9.12 DMA Results

Table 26: DMA Inlet

Sr. No	Name of DMA	DMA Inlet (MLD)
1	Indra Nagar	0.62
2	Rajajipuram	2.01
3	Gomti Nagar	3.58
4	Jiya Mau	1.28
5	Vastu Khand	2.06
6	Ruchi Khand	3.74
7	Ratan Khand	0.78
8	Viram Khand	2.35
9	Eldico	1.47
10	Ashiyana Sec. G1 & D	7.98
11	Aliganj	1.87
	Total in (MLD)	**27.74**

4.2.10 Consumer Survey

4.2.10.1 Questionnaire

The collected survey data included:

- Name of the consumer
- Consumer house number/GIS plot ID
- Length and Area of consumer property
- Water supply timings
- Number of persons per connection
- Number of domestic, industrial, institutional and non-domestic consumers
- Distribution of consumers based on the floor levels of their properties
- Date and time of survey

All the data obtained was updated on a mobile application to increase the accuracy of results and minimize human intervention. Average number of persons per connection is obtained as 5. The average supply hours per day are 6 hours.

4.2.10.2 Sampling

All the properties in the DMAs were surveyed with 100% sampling. However, the bucket test was carried out for volumetric analysis on sampling basis and then extrapolation was done to 100%. Sampling for volumetric survey was around 13% within each DMA.

Consumer survey was conducted in all 11 DMAs to gauge the demand and supply side parameters from end users' perspective. The survey helped build understanding on interruptions, continuation, connection, billing, etc. The personnel conducting the survey were authorized by LMC as well.

4.2.10.3 Consumer and Water Supply Profiling

<u>Consumer Survey Results:</u>

Table 27: Consumer Survey Detailed Analysis

Sr. No.	Area	Number of Consumer	Avg. Supply Hrs/property	Avg. Population Per Property
1	Indra Nagar	1370	6	5
2	Gomti Nagar	1605	6	5
3	Rajajipuram	1747	6	5
4	Jiya Mau	814	3	6
5	Vastu Khand	1569	5	6
6	Ruchi Khand	3370	5	5
7	Ratan Khand	474	5	5
8	Viram Khand	1751	5	5
9	Eldico	1532	5	5
10	Ashiyana Sec. G1 & D	7459	5	5
11	Aliganj	1206	3	6
Total/Average		**22897**	**5**	**5.22**

4.2.10.4 Consumer Level Flow Measurements

NRW Projects' Volumetric flow measurements consist of details related to volume and pressure of the water at consumers' premises. The details collected will include Consumer house number/GIS plot ID, name of consumer, plot number, consumer number, type of connection, date and time of survey to maintain credibility of the data. Along with above mentioned data, flow of water will also be measured along with pressure. Photograph is mandatory to build reliability in the process of data collection.

The application has a feature by which the surveyor has the option to send the recorded data at the time of recording or he can save the details at that time and send all details at later point of time. This will help the surveyor to continuously carry on with the data collection without wasting any time for synchronizing with the cloud based database.

Detailed volumetric method is included in the Annexures.

As the field team did not get permission to install meters at consumer end, LMC suggested to adopt alternate method for consumer flow measurements. Hence, Ceinsys went ahead and undertook stop watch-bucket testing method.

4.2.10.5 Volumetric – Calibrated Measuring Bucket Testing Method & Measurement with ultrasonic based consumer meter:

The simplest way to measure volumetric flow is to measure how long it takes to fill a known volume container. A simple example is using a container of known volume, filled by a fluid. The stopwatch is started when the flow starts, and stopped when the container starts to overflow. The volume divided by the time gives the flow. This method can be employed for measuring the flow of well sources.

Also the temporary digital ultrasonic Consumer meters were installed at sample connections. there were taken volumetric readings by digital ultrasonic meter .

Figure 53: Calibrated Bucket measurement method of Volumetric Flow Measurements

Figure 54: Ultrasonic based consumer meter measurement method of Volumetric Flow Measurements

Based on special application for volumetric flow measurement, activity of measurement was being done at 11 DMA's and results are tabulated below:

Table 28: DMA Consumption

Sr. No.	Area	Number of Properties in DMA	Properties for flow measurement study	Avg. Supply Hrs / property	Avg. Population Per Property	Average (Litres/hour) per property	Total Consumption in MLD
1	Indra Nagar	1370	162	6	5.00	64.75	0.53
2	Gomti Nagar	1605	210	6	5.00	225.97	2.18
3	Rajajipuram	1747	237	6	5.00	158.45	1.66
4	Jiya Mau	814	163	3	6.10	335.45	0.82
5	Vastu Khand	1569	314	5	5.50	217.83	1.71
6	Ruchi Khand	3370	674	5	5.00	185.00	3.12
7	Ratan Khand	474	95	5	4.80	240.98	0.57
8	Viram Khand	1751	350	5	5.00	211.97	1.86
9	Eldico	1532	306	5	5.00	144.97	1.11
10	Ashiyana Sec. G1 & D	7459	1492	5	5.00	162.00	6.04
11	Aliganj	1206	241	3	6.00	294.00	1.06
Total/Average		**22897**	**4244**	**5**	**5.22**	**203.76**	**20.66**

Table 29: Losses at DMA level

Sr. No	Name of DMA	DMA Consumption (MLD)	DMA Inlet (MLD)	DMA Loss (MLD)	Avg. DMA Loss (%)
1	Indra Nagar	0.53	0.62	0.09	13.82%
2	Rajajipuram	1.66	2.01	0.35	17.43%
3	Gomti Nagar	2.17	3.58	1.41	39.25%
4	Jiya Mau	0.82	1.28	0.46	35.99%
5	Vastu Khand	1.71	2.06	0.35	17.06%
6	Ruchi Khand	3.12	3.74	0.62	16.65%
7	Ratan Khand	0.57	0.78	0.21	26.79%
8	Viram Khand	1.86	2.35	0.49	21.02%
9	Eldico	1.11	1.47	0.36	24.44%
10	Ashiyana Sec. G1 & D	6.04	7.98	1.94	24.29%
11	Aliganj	1.06	1.87	0.81	43.12%
	Total/Average	**20.66**	**27.74**	**7.08**	**25.44%**

Table 30: LPCD Calculations from DMA Study and Analysis

Sr. No	Name of DMA	Total Population	DMA Consumption (MLD)	LPCD
1	Indra Nagar	6850	0.53	78
2	Rajajipuram	8735	1.66	190
3	Gomti Nagar	8025	2.17	271
4	Jiya Mau	4965.4	0.82	165
5	Vastu Khand	8629.5	1.71	198
6	Ruchi Khand	16850	3.12	185
7	Ratan Khand	2275.2	0.57	251
8	Viram Khand	8755	1.86	212
9	Eldico	7660	1.11	145
10	Ashiyana Sec. G1 & D	37295	6.04	162
11	Aliganj	7236	1.06	147
	Total in (MLD)	**117276.1**	**20.66**	**182.2**

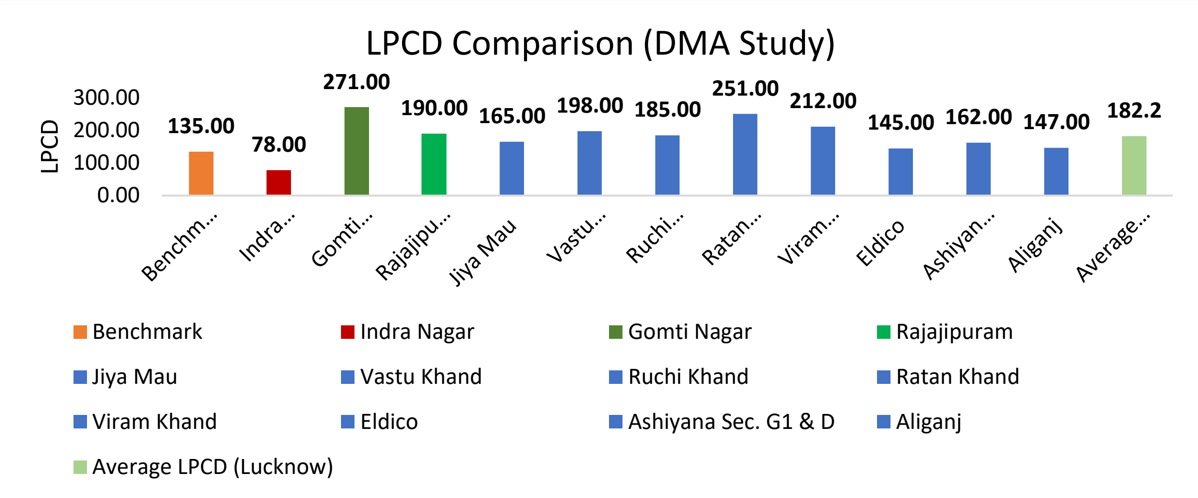


Figure 55: LPCD Comparison Chart

The DMA study shows that average LPCD is 182.2 litre, but the range of LPCD in the selected DMA's is from 77 to 271 litre this shows Lucknow doesn't have equitable water supply system. Beside this there is direct usage of ground water in distribution system and mixing of ground water with treated surface water is also observed, LMC water supply scheme should take this up on priority to resolve the issues on ground by taking corrective action.

4.2.10.6 Extrapolation to entire city

As per above study there is 182.2 LPCD rate which is extrapolated to 379810 ARV data which is provided by LMC, also it is clear that there is average 5 persons per property and results are extrapolated below:

Table 31: LPCD Extrapolation and Revenue Water Calculations

LPCD	# of properties as per ARV	Average population per property	Total population	Total authorised consumption (MLD)
182.2	3,79,810	5.22	19,82,608	361.23

4.3 WATER BALANCE

Data and measurement is analysed to develop the water and cost balance sheet. The total water audit analysis is carried out in nine tasks as explained below

4.3.1 Determining System Input Volume

The volume of treated water input to that part of the water supply system to which the water balance[19] calculation relates.

System Input Volume = Own Sources + Water Imported

- Own Sources: The volume of (treated) water input to a distribution system from the water supplier's own sources allowing for known errors (for example source meter inaccuracies). The quantity should be measured after the utility's treatment plant(s). If there are no meters installed after the treatment plant, the output must be estimated based on raw water input and treatment losses. In case of Lucknow, we are taking raw water intake as system input volume to the water supply system
- It is important to note that water losses at raw water transmission pipelines and losses during the treatment process are not part of the Annual Water Balance calculations shown in this report. However, a separate audit of the transmission system and water treatment works can be performed if desired.
- Water Imported: The volume of bulk supplies imported across operational boundaries. Water imported can be either
  - Measured at the boundary meter (if already treated)
  - Measured at the outflow of the treatment plant (if raw water is imported and there is a separate treatment plant)
  - In either case, corrected for known errors (for example transfer meter inaccuracies)

In case of Lucknow, imported water is zero

- Mix of raw water: If raw waters imported are mixed with own source raw water in the treatment plant, there is no need for a differentiation and the total production (output) of this one or more plant(s) is used as basis for the System Input. As always, corrections must be made for known errors as with the 'Own Sources', it is important to note that water losses at raw water transmission systems and losses during the treatment process are not part of the Annual Water Balance calculations. In case the utility has no distribution input meters, or they are not used, and the key meters are the raw water input meters, because these are the meters that they buy the raw water on, the system input must be based on the raw water meters and treatment plant use/loss has to be considered

As per as Is Assessment, Lucknow water supply scheme draws water from two sources – surface and ground water. Here, system input volume is considered as sum of both –

---

[19] Real Loss Component Analysis by Water Research Foundation

i) Raw water lifted from surface water for treatment through WTP
ii) Ground water

4.3.2 Surface Water

There are no fixed type inline bulk flow meters in the water supply system. During the study, portable clamp on type portable ultra-sonic flow meters were used for taking the reading on quantum of water flowing through. The readings were taken by deploying teams with the instruments at various stages for measurement for total of 24 hours' period. The results of the study on surface water were elaborated in the 1st interim report summarized below.

Table 32: Raw Water Intake from 1st Interim

S. N.	Surface Water Source	Raw water Intake (MLD)
1	Gaughat for Aishbag WTP	240.77
2	Gaughat for Balaganj WTP	139.50
3	Sharda Sahayak canal for 80 MLD WTP	87.58
Total (MLD)		**467.85**

4.3.3 Ground Water

There are 708 bore wells with 68 bore wells not in working condition. Ground water is lifted using 640 bore wells which are equipped with the motor pumps varying in the range of 5 to 30 HP.

Table 33: Tube wells Status at Zonal Level

Capacity of Pump used for Ground Water	Status	Zone-1	Zone-2	Zone-3	Zone-4	Zone-5	Zone-6	Zone-7	Zone-8	Total
5 HP	Working	9	-	-	-	-	-	-	1	10
7.5 HP	Working	9	1	-	5	-	-	-	9	24
	Not Working	-	2	-	-	-	-	-	-	2
10 HP	Working	7	6	14	5	-	-	6	8	46
	Not Working	4	4	-	-	-	-	-	1	9
12.5 HP	Working	2	-	-	-	-	-	-	-	2
15 HP	Working	23	23	23	18	-	-	16	6	109
	Not Working	2	4	-	-	-	-	-	-	6
17.5	Working	2	1	-	-	-	-	-	2	5
20 HP	Working	36	21	60	32	-	-	40	62	251
	Not Working	1	2	-	-	-	-	-	3	6
25 HP	Working	1	-	33	25	-	-	19	15	93
30 HP	Working	-	-	6	-	-	-	-	1	7
HP (HP not available)	Working	-	-	3	-	47	43	-	-	93
	Not Working	1	-	4	5	4	13	16	2	45
	Total	**97**	**64**	**143**	**90**	**51**	**56**	**97**	**110**	**708**

Total water extracted from 708 Nos. of bore wells is 329.52 MLD.

Thus,

System Input Volume = 467.85 + 329.52 = 797.37 MLD

4.3.4 Authorized Consumption

The volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so by the water supplier, for residential, commercial and industrial purposes. It also includes water exported across operational boundaries.

Authorized consumption may include items such as firefighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, building water, etc. These may be billed or unbilled, metered or unmetered.

4.3.5 Billed Authorized Consumption

Those components of Authorized Consumption which are billed and produce revenue (also known as Revenue Water). Equal to Billed Metered Consumption plus Billed Unmetered Consumption.

Please note that average quantity is considered for billing as per consumer data.

4.3.6 Billed Metered Consumption

All metered consumption which is also billed. This includes all groups of customers such as domestic, commercial, industrial or institutional and includes water transferred across operational boundaries (water exported) which is metered and billed.

In Lucknow with 0% metering at consumer end,

Billed metered consumption is 0 MLD

4.3.7 Billed Unmetered Consumption

All billed consumption which is calculated based on estimates or norms but is not metered. This might be a very small component in fully metered systems (for example billing based on estimates for the period a customer meter is out of order) but can be the key consumption component in systems without universal metering. This component might also include water transferred across operational boundaries (water exported) which is unmetered but billed.

For Lucknow, all registered connection consumers fall in the billed unmetered consumption category. Hence,

Billed Unmetered Consumption = 361.23 MLD

Thus, Billed Authorized Consumption = Billed Metered Consumption + Billed Unmetered Consumption

= 0.0 MLD + 361.23 MLD

= 361.23 MLD

System Input Volume (Surface Water+ Ground Water 797.37 MLD)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption (0 MLD)	Revenue Water
	--	361.23 MLD 45.30%	Billed Un Metered Consumption (361.3MLD) 45.30%	361.23 MLD 45.30%

Non-Revenue Water = System Input Volume – Revenue Water

= 797.37 – 361.23

= 436.14 MLD

4.3.8 Unbilled Authorized Consumption

Those components of Authorized Consumption which are legitimate but not billed and therefore do not produce revenue. Equal to Unbilled Metered Consumption plus Unbilled Unmetered Consumption.

- Public stand post water supply
- Tanker water supply
- Corporation offices, Schools, Hospitals.
- Public Parks & Gardens (old)
- Public Urinals and toilets.

In Lucknow, following are the unbilled but authorized consumers –

1. Stand Post Consumption
2. Tanker Water Supply: - LMC provides water supply by tanker as per demand
3. Gardening Consumption

4.3.9 Unbilled Metered Consumption

Unbilled Metered Consumption = 0 MLD

Note: As there is no metered water supply in Lucknow city, consumption under this category will be Zero.

4.3.10 Unbilled Unmetered Consumption

4.3.10.1 Stand Post Consumption:

There are total 5855 stand posts in Lucknow city. Average 4 families depend on one stand post.

Average family size is 5.22 souls per family and LPCD is 182.2 liter.

Total consumption of all Stand Post = 5855 X 182.2 X 5.22 X 4

= 22274387 Liters = 22.27 MLD

4.3.10.2 Tanker Supply Consumption:

LMC supplies the water to consumers and for public toilet using tanker supply as per demand,

Capacity of each tanker is 4000 Liters

Total Nos. of Tankers are 48 Nos.
Average trips per day of each tanker are 3

Consumption of Tanker supply = 4000 X 48 X 3
= 5,76,000 Liters
= 0.576 MLD

4.3.10.3 Gardening Consumption:

Consumption for gardening is considered as 5% of Billed unmetered consumption as per the discussion with LMC officials,

Consumption of Gardening = 361.23 x 5%
= 18.061 MLD

Un-Billed Un-Metered Consumption = 22.27 + 0.576 + 18.061
= 40.908 MLD

Un-Billed Authorized Consumption = Un-Billed Metered Consumption + Un-Billed Unmetered Consumption
= 0.0 MLD + 40.908 MLD
= 40.908 MLD

4.3.10.4 Water Losses

The difference between System Input Volume and Authorized Consumption. Water losses can be considered as a total volume for the entire system, or for partial systems such as transmission or distribution systems, or individual zones. Water Losses consist of Real Losses and Apparent Losses.

Water Losses = System Input Volume - Authorized Consumption
= 797.37 – 402.14
= 395.23MLD

4.3.10.5 Apparent Loss

Includes all types of inaccuracies associated with customer metering as well as data handling errors (meter reading and billing), plus unauthorized consumption (theft or illegal use). It is important to note that reducing apparent losses will not reduce physical water losses but will recover lost revenue. Note: Over-registration of customer meters, leads to under-estimation of Real Losses. Under-registration of customer meters, leads to over-estimation of Real Losses.

Apparent Losses = Un-authorized Consumption + Metering Inaccuracies

4.3.10.6 Un-authorized Consumption:

Estimated illegal consumers

Currently LMC's billing depend on Annual Rental Value of the Properties. Extent of the illegal connections can be drawn only after detailed consumer survey and consumer indexing. Here we have considered 3% illegal consumers across the water supply coverage.

Hence, **Un-authorized consumption** = 3% (Billed unmetered consumption) = 361.23 X 3% **= 10.84 MLD**

4.3.10.7 Metering Inaccuracies:

- Raw Water Measurement Losses
- Losses at Pump House
- Measurement Losses in Distribution System

Customer Billing Inaccuracies = NIL

Water Supply is completely unmetered throughout the LMC. During study, the Ceinsys team was not allowed to install the meters at consumer end due to protest from the local public for DMA study, hence billing inaccuracy is not considered in the water balance.

Apparent Losses = Un-authorized Consumption + Customer Billing Inaccuracies = 10.84 MLD

4.3.10.8 Real Losses

Physical water losses from the pressurized system and the utility's storage tanks, up to the point of customer use. In metered systems this is the customer meter. In unmetered situations this is the first point of use within the property. The annual volume lost through all types of leaks, breaks and overflows depends on frequencies, flow rates, and average duration of individual leaks, breaks and overflows.

Note: Although physical losses, after the point of customer use, are excluded from the assessment of Real Losses, this does not necessarily mean that they are not significant or worthy of attention for demand management purpose.

Real Losses = Water losses – Apparent losses
=395.23 – 10.84 = 384.40 MLD

There are following reasons of real losses in water system, some of them are applicable in Lucknow.

i. Leaks at raw water transmission
ii. Evaporation losses.
iii. Water treatment losses.
iv. Leaks / seepage of reservoirs.
v. Overflows of reservoirs.
vi. Leaks of distribution mains.
vii. Leakages from valves & air valves.
viii. Leakages from service connections up to meter.
ix. Leakages in consumer premises after the meter (not in scope of water audit).

4.3.11 Leakages in Raw Water Transmission & Treatment losses (Surface water):

S.N.	Source	Raw water Intake (MLD)	WTP Outlet (MLD)	Total Water Loss (MLD)
1	Gaughat for Aishbag	240.77	210.92	29.85
2	Gaughat for Balaganj	139.50	124.08	15.42
3	Sharda Sahayak canal	87.58	86.09	1.49
Total (MLD)		**467.85**	**421.09**	**46.76**

Total Leakage in RW Transmission & Treatment Loss = Raw Water Intake – WTP Outlet

= 467.85 – 421.09

= 46.76 MLD

4.3.12 Leakages in Pure water transmission and Distribution Losses & leakages on service connections up to point of customer connections using top down approach.

= Real Losses – Raw water transmission losses & treatment losses

= 384.40 – 46.76

= 337.64 MLD

5 WATER BALANCE AND LOSSES

Table 34: Lucknow Water Balance

<table>
<tr>
<td rowspan="8">System Input Volume
Surface Water + Ground Water
467.85 + 329.52
797.37 MLD
100%</td>
<td rowspan="4">Authorized Consumption
402.14 MLD
50.43%</td>
<td rowspan="2">Billed Authorized Consumption
361.230 MLD
45.30%</td>
<td>Billed Metered Consumption
0.000 MLD
0.00%</td>
<td rowspan="2">Revenue Water
361.23 MLD
45.30%</td>
</tr>
<tr>
<td>Billed UnMetered Consumption
361.230 MLD
45.30% %</td>
</tr>
<tr>
<td rowspan="2">Unbilled Authorized Consumption
40.908 MLD
5.13%</td>
<td>Unbilled Metered Consumption
0 MLD
0.00 %</td>
<td rowspan="6">Non Revenue Water
436.14 MLD
54.70%</td>
</tr>
<tr>
<td>Unbilled Unmetered
Tanker + PSP+ Gardening
40.908 MLD
5.13%</td>
</tr>
<tr>
<td rowspan="4">Water Losses
395.232 MLD
49.57%</td>
<td rowspan="2">Apparent Losses
10.837 MLD
1.36%</td>
<td>Unauthorized Consumption
3%
10.837 MLD
1.36%</td>
</tr>
<tr>
<td>Customer Billing
NIL MLD
0 %</td>
</tr>
<tr>
<td rowspan="2">Real Losses
384.40 MLD
48.21%</td>
<td>Leakages in Raw Water Transmission & Treatment Losses
46.76 MLD
5.86%</td>
</tr>
<tr>
<td>Leakages in Pure Water Transmission and overflow & Distribution Losses & Leakages on Service Connections up to Point of customer Meter
337.64 MLD
42.34%</td>
</tr>
</table>

6 NRW REDUCTION STRATEGY

6.1 APPROACH TO NRW REDUCTION LUCKNOW

The overall approach to NRW reduction involves implementation of key strategies for Base Map and Audit, Source Side Repair, Maintenance and Metering, Apparent Loss Reduction and Real Loss Reduction and continuous NRW monitoring activities to maintain the NRW level. The below diagram represents the integration of various essential activities, those will reduce the water losses.

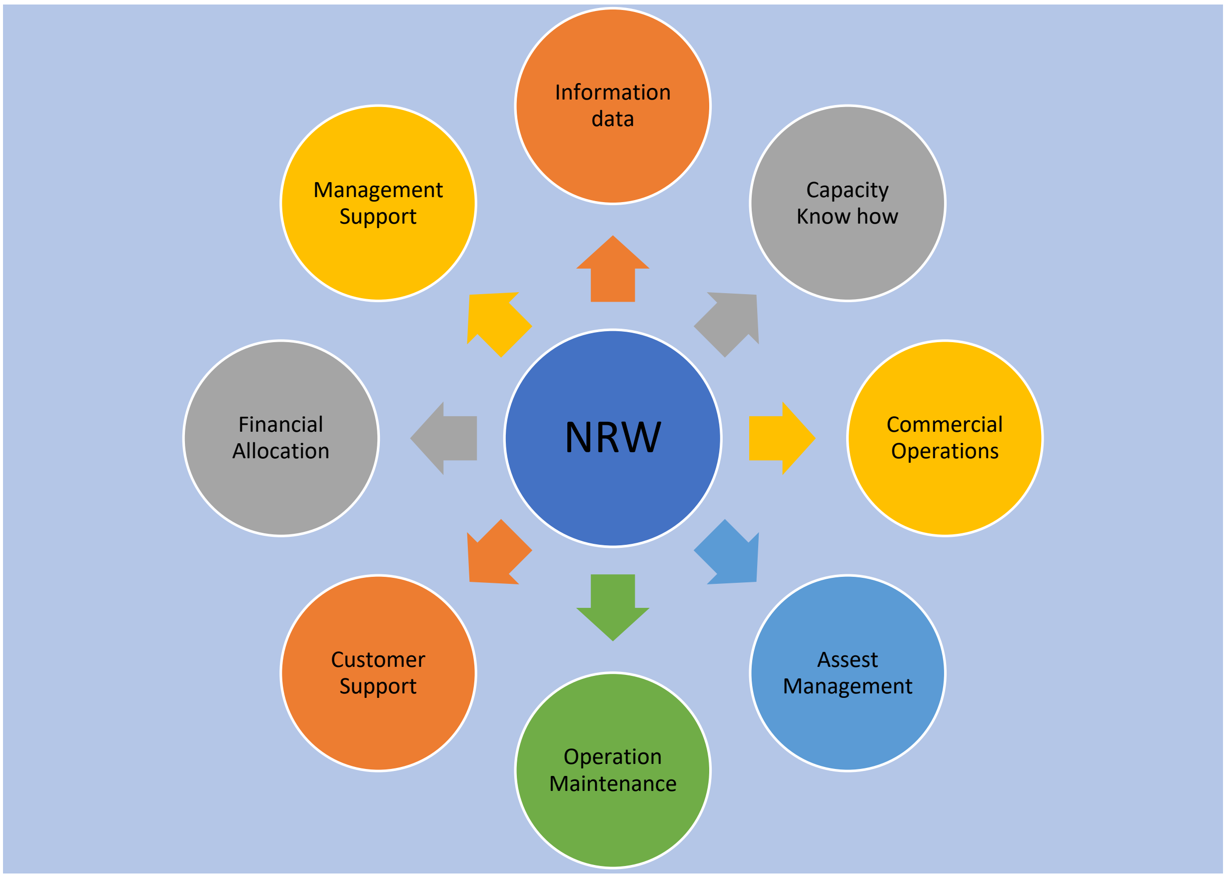


Figure 56: Reducing NRW is everyone's responsibility

6.2 FEED REQUIREMENT AND OBJECTIVE

Further reference to our DMA study and assessment along with field visits and site surveys, below details are not available for Lucknow, thus making it difficult to proceed on detailing out exact project plan with costs and estimates.

Lack of details on below heads,

- Water transmission and distribution network map of Lucknow
- Topographical details
- No GIS data or system in place
- Consumer category bifurcation for total population
- Water consumption details for different category of consumers
- Details of water supply assets like material, length, age, etc.

- Hydraulic modelling of existing water supply system.
- Leakage history and available mechanisms to control leaks

There is lack of important databases for Lucknow; hence we are strongly recommending the NRW reduction strategy in following phases,

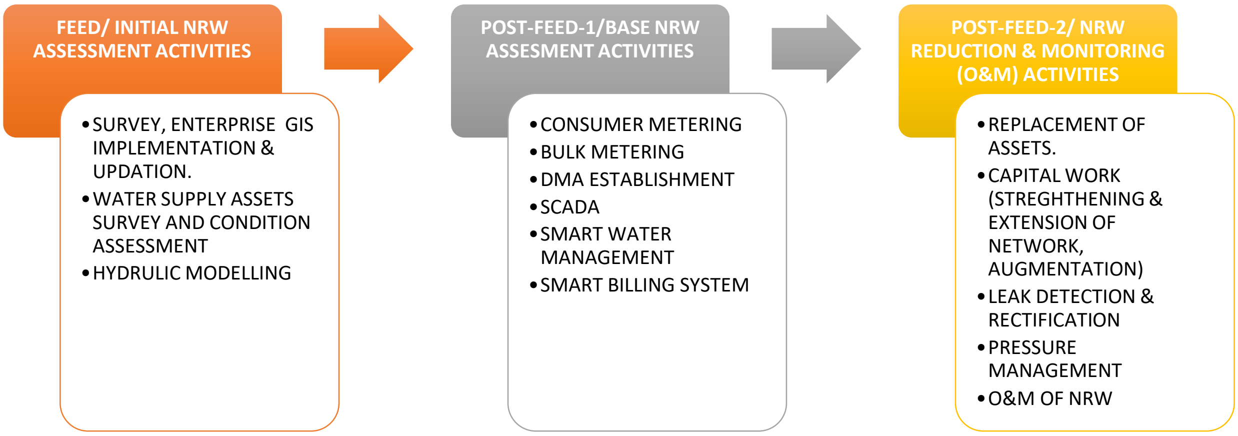


Figure 57 : Proposed NRW reduction phases

6.3 WHAT IS FEED

Front-End Engineering (FEE), or Front-End Engineering and Design (FEED), is an engineering design approach used to control project expenses and thoroughly plan a project before a fix bid quote is submitted. It may also be referred to as Pre-project planning (PPP), front-end loading (FEL), feasibility analysis, or early project planning.

It is the work required to produce quality process and engineering documentation of sufficient depth, defining the project requirements for detailed engineering, procurement and construction.[20]

The technical and commercial outcomes from the FEED methodology,

- Evaluate options that will improve the return on assets (ROA)
- Prepare cost estimates for scope definition and for project funding
- Support internal funding requirements
- Completion of pre-financing portion of the engineering which included process, mechanical, civil, structural and water engineering for the project scope
- Confirmation of the expected performance backed by commercial guarantees
- Technical and execution planning in sufficient detail to support a highly-accurate EPC cost estimate and a firm price commercial offer for Project execution
- A design meeting the industry standards for integrity, operability, availability, safety, and environmental profile
- An annual O&M cost estimate for the water supply system.

[20] http://www.fluor.com/services/engineering/front-end-engineering-design

6.4 FEED IMPLEMENTATION FOR LUCKNOW

Furtherance to the field survey, it is mandatory to implement the FEED (initial NRW assessment) to reduce the NRW in effective manner as well as plan for new augmentation.

6.4.1 Brief description of FEED activities in Lucknow

The FEED activities can also be called as Initial NRW assessment activities are explained in this section as below.

6.4.2 Survey and Investigation Work and development and continuous Updation of GIS:

This is the first step of NRW assessment, a site test survey should be undertaken to identify and map the existing pipes their alignment, type of material, size and length and associated valves. This survey is also undertaken to determine the number of consumers, road names, details of properties, and source of water supply. The objective of this survey will provide the clear details about the water supply system and present health condition, current operation system, as well as it will provide the details of consumers from which we can easily analyse and avoid the apparent losses such as illegal connections. Each step related to survey as described below.

6.4.3 Enterprise GIS implementation and updation:

Geographic Information Systems (GIS) are an effective tool for storing, managing, and displaying spatial data often encountered in water resources management. The mandate was to establish a proper water distribution network and a system for measuring non-revenue water (NRW).

- GIS is defined as a system of capturing, storing, manipulating, analysing, and displaying spatial information in an efficient manner.
- It can be characterized as a software package that efficiently relates graphical information to attribute data stored in a database and vice-versa.
- Also all the topographical survey carried out with high end technology and the results will be directly incorporated in GIS.
- GIS provides tools to improve efficiency and effectiveness when working with map and non-graphic attribute data.
- A data input subsystem which collects and/or processes spatial data derived from existing maps, remote sensors, etc. The data input is usually accomplished
- using computer tapes, digitizers, scanners or manual encoding of geographically registered grid cells, points, lines, polygons or tables.
- A data storage and retrieval subsystem which organizes the spatial data in a form that permits it to be quickly retrieved by the user for subsequent analysis, as well as allows for rapid and accurate updates and corrections to be made to the spatial database.
- Typical directories include: land cover, soils imagery, topography, roads, land marks, and water network information such as reservoirs, transmission & distribution pipelines, associated valves, consumer locations, leakage hotspots etc. as well as sewage network details can be incorporated.

- A data manipulation and analysis subsystem which converts data through user defined aggregation rules, or produces estimates of parameters and constraints for various space-time optimization or simulation models.
- A data reporting subsystem which displays all or part of the original database, as well as manipulated data, and the output from spatial models in tabular or map form.
- The entire GIS database related to water supply is in one place and can be updated at any point of time. All the consumers are now uniquely numbered and same reference can be used for further monitoring work.
- A sustainable and a centralized water supply network can be used for hydraulic modelling for design of strengthening of network and new augmentation based on future demand and monitoring of real-time flow and pressure as well as improvement in distribution network, analysis of time of rehabilitation of assets and active leakage control as well as pressure management by integration with software and SCADA. The schematic diagram of GIS web based system as mention below.

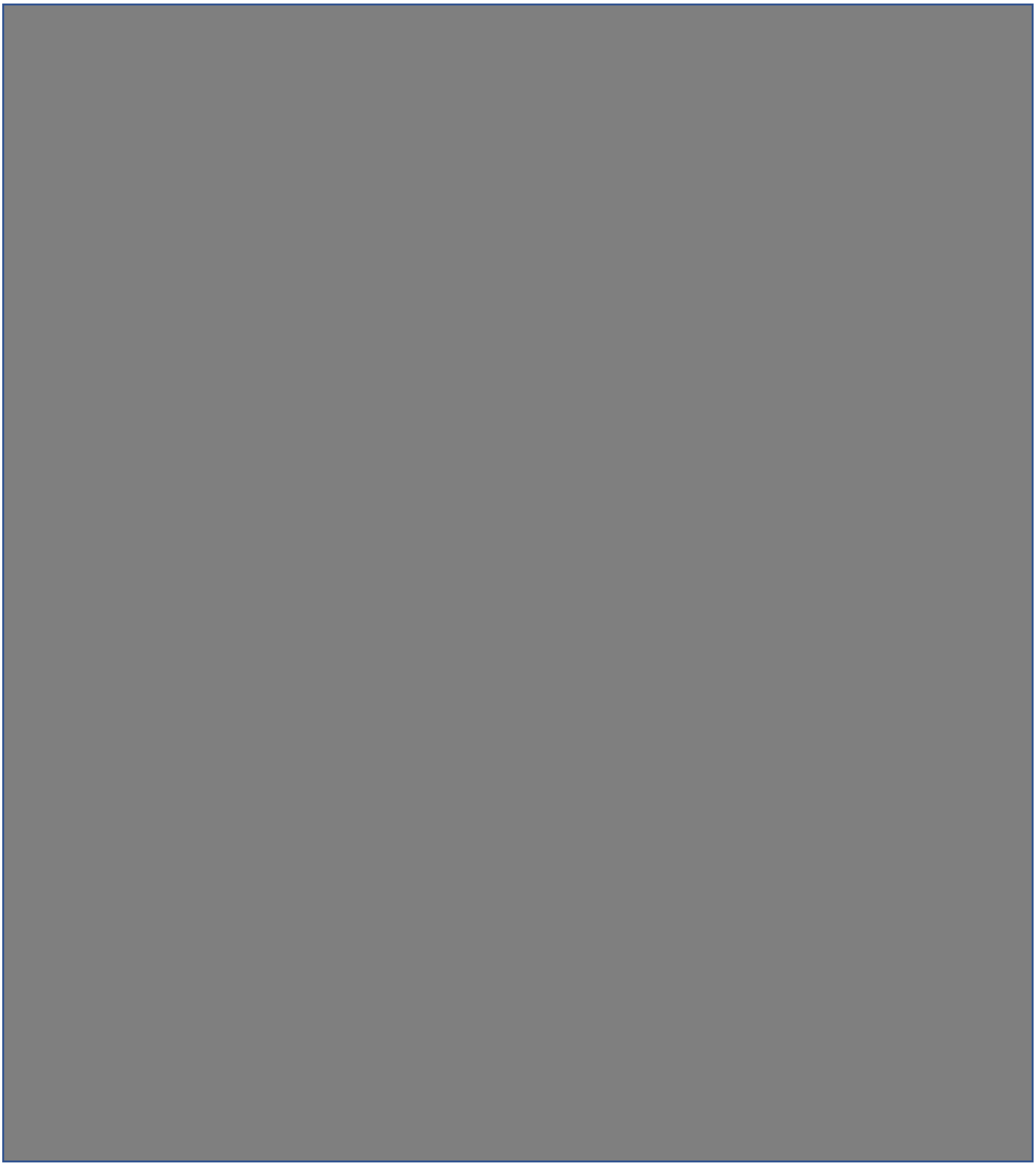


Figure 58: Schematic Architecture of web based GIS system

According to the survey Lucknow municipality corporation did not established the GIS based system, hence it is recommended to implement the GIS based setup such as GIS data centre for monitoring and DEM, 1M contour generation including Stereo pair satellite images to develop the GIS Lucknow based. After development of GIS the data updation to be carried out which we have obtained during various survey. Also, it is mandatory to update the GIS data during the entire life cycle of the water supply system to keep the database up to date.

6.4.4 Customer door to door survey

This will involve collecting demographic, economic, social, etc. information about the customer such as number of occupants, details of property, details of connection like size, material, age, status of meter, working condition of meter, other source of water supply to the customer, details of storage tank of the properties, water supply time, pressure at the consumer premises, co-ordinates of property which we can upload in GIS through GPS devices etc. This helps to prepare the strong customer database.

6.4.5 Underground asset survey including type and conditions

Further reference to the study from Lucknow, the details of existing underground utilities are not available, hence it is strongly recommended to undertake the underground asset survey to understand the pipeline network, material of the pipes, size and age, condition of the pipeline with the associated valves. These activities can be carried out by carry out no of trail pits along the entire network of water supply system. This helps to make strong asset data base as well as which will indicate the time of rehabilitation of asset also these are the basic parameters for asset management.

6.4.6 Updation of GIS

It is mandatory to update the GIS according to the changes incurred in the real field in day to day basis. Also, it is continuous and life time activity to keep the data base updated. The following points can be updated in GIS map as mentioned below,

a) Water supply system assets details such as pipeline, reservoirs, valves, WTP, pumping stations etc.
b) Roads, streets, landmarks etc.
c) Details of consumers
d) Leak hotspots
e) Details of flow meters, pressure loggers, PRV details, transmitters also the hyperlinks of the same to assess the data
f) Details of DMA boundaries, zone boundary.
g) Details of step test design in each DMA with step test valves and boundary valves details.
h) Topographical details such as ground level elevation, etc.

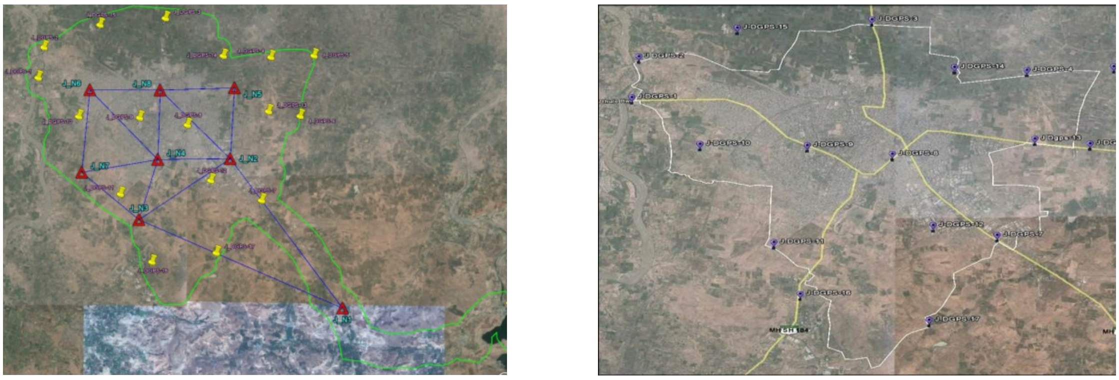


Figure 60: Typical representation of GIS map.

6.4.7 Development of Network Hydraulic Model:

The hydraulic model for the water supply system is a mathematical approximation of a real system. This can be developed after the development of GIS. As per Lucknow water supply system initially the offline network to be developed (High level model), to understand and analyse the condition of hydraulics based on existing network. Also, the strategic model can be developed to analyse requirements for strengthening of water supply system based on future demands.

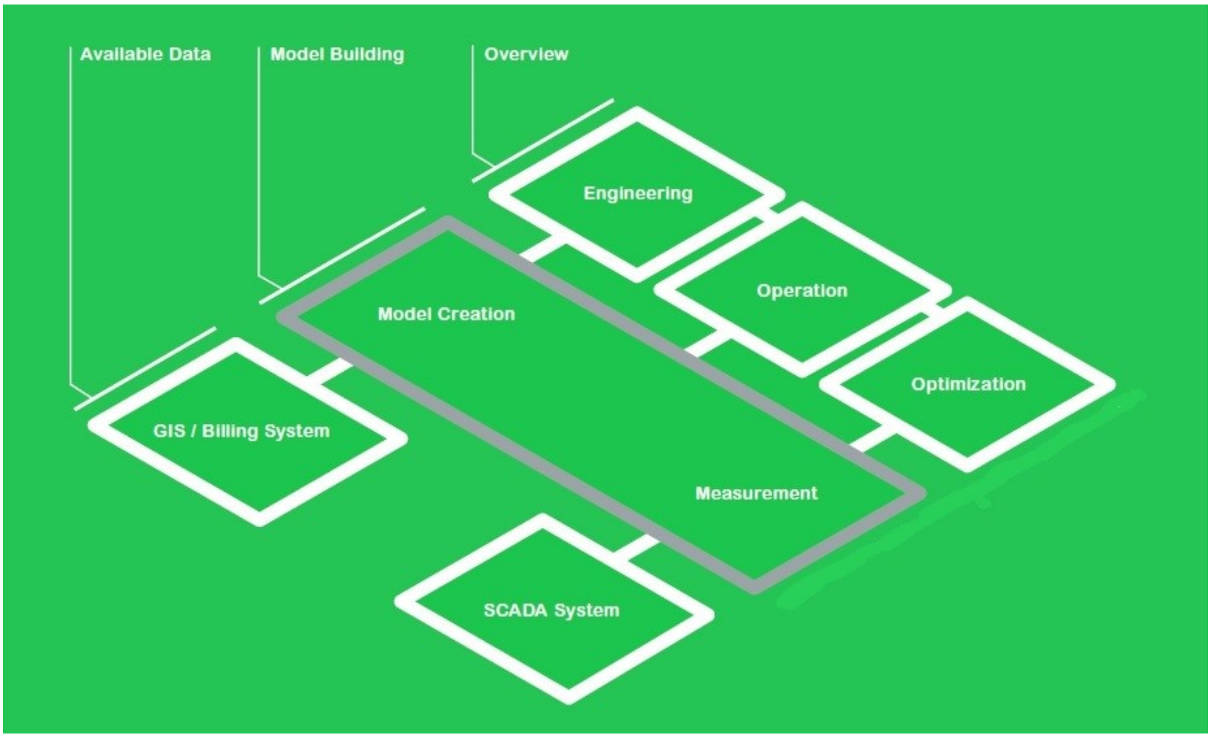


Figure 61: Schematic Diagram of application of SCADA and Hydraulic modelling & GIS

6.4.8 Development of High-Level Model and Strategic model

The High-level model can be used for many purposes such as,

Dividing a large system into a number of smaller sub systems such as pressure zones and District Meter Areas (DMA), this is one of the best practices for water loss / leakage management a part of NRW reduction activities. This model will provide the requirements of strengthening activities and analysis of new augmentation based on future demand and current pressure demand/dependant of the water distribution network. The strategic model is nothing but the calibrated model of High level model of the water supply system. This model can be used for performing critical analysis and evaluating pipe renewal and replacement alternatives. Designing and evaluating pressure management strategies by performing the simulation analysis of the leakage reduction impact of different control scenarios.

Figure 62: Typical diagram of offline model

6.5 POST-FEED ACTIVITIES:

In continuation with the present condition Lucknow water supply system, it is difficult to derive the actual cost for NRW reduction activities (POST-FEED 1 & 2), since it not feasible to derive the quantity of asset replacement, DMA establishment, Leak detection and rectification, pressure management, NRW – management (O&M) etc. without completion of FEED (Initial NRW assessment activities). However, in this section describing the list of POST-FEED activities involves in base NRW assessment and NRW reduction and monitoring, O&M. Implementation of activities related to POST-FEED 1 & 2 will be based on priority and fund availability of concerned municipal corporation (LMC).

6.6 Implementation of Base NRW assessment activities (POST-FEED 1):

The POST-FEED-1 also known as base NRW assessment activities, the details of each activity involve in base NRW assessment described in this session. Base NRW assessment activities categorized in to following heads:

- Consumer metering
- Source/ Transmission metering
- Finalization of DMA boundary and DMA establishment with DMA metering.
- Implementation of SCADA and online monitoring system.
- Smart water management and real time network optimization.
- Smart water billing.

6.6.1 Metering System

6.6.1.1 Consumer level New Metering

One of the essential strategies of NRW is consumer metering, as of now at Lucknow metering system not established and at present the water bill is being recovery from the consumer vide ARV (Annual rental value) only. Hence it is strongly recommended to change the billing system from ARV to metering system. After installation of the consumer meter LMC/NRW team can derive the absolute water balance and real losses. Hence it is strongly recommended to install consumer meters before starting the NRW reduction activities, due to this LMC can derive the actual water balance as well as can improve the revenue. Herewith it is recommended to install Class B or AMR/AMI – UFM/EMF type meters to increase the accuracy of the measurement which will improve the revenue.

6.6.1.2 Automatic Meter Reading (AMR)

AMR is a technology which automatically collects metering data and transfers that data to a central database for analysis and billing purposes, generally called "smart meters". Detailed water usage data can be collected continuously at regular intervals (for example, every 30 minutes) and can be read remotely via an automated process, with the usage data sent to the utility's management and billing system. AMR can consist of a number of various methods, ranging from a simple drive-by meter (where the meter reader cruises down the street automatically downloading the meter data) to one-way communications with the utility.

AMR, is the technology of automatically collecting consumption, diagnostic, and status data from water meter or energy metering devices (gas, electric) and transferring that data to a central database for billing, troubleshooting, and analysing. This technology mainly saves utility providers the expense of periodic trips to each physical location to read a meter. Another advantage is that billing can be based on near real-time consumption rather than on estimates based on past or predicted consumption. This timely information coupled with analysis can help both utility providers and customers' get better control over the use and production of electric energy, gas usage, or water consumption.

AMR technologies include handheld, mobile and network technologies based on telephony platforms (wired and wireless), radio frequency (RF), or power line transmission.

Originally AMR devices just collected meter readings electronically and matched them with accounts. As technology has advanced, additional data could then be captured, stored, and transmitted to the main computer, and often the metering devices could be controlled remotely. This can include events alarms such as tamper, leak detection, low battery, or reverse flow. Many AMR devices can also capture interval data, and log meter events. The logged data can be used to collect or control time of use or rate of use data that can be used for water or energy usage profiling, time of use billing, demand forecasting, demand response, rate of flow recording, leak detection, flow monitoring, water and energy conservation enforcement, remote shutoff, etc.

This will keep a check on the water lost at every stage and if that is above permissible limit then strict actions need to be taken at that processing stage to analyse the causes of the losses and arrest them.

6.6.1.3 Advanced Metering Infrastructure (AMI)

AMI starts with smart meters and adds two-way communication between the meter and utility, and between the meter and consumer. This means that in addition to providing readings, the meter can also receive (and often act on) instructions sent from the utility or consumer.

AMI data's gives a very detailed information where the utility can run hourly consumption reports that pinpoint miniscule leaks, or tell customers how much water they have used.

AMIs are comparatively expensive. If there are constraints in the budget, then AMR can be installed to start with. AMR installations can be done after analyzing all performance parameters, evaluation and implementation schedule.

After graduating to AMI, further enhancements that can be taken up are –

- Integrate distribution system (remotely identify location and extent of water main breaks, control water loss during breaks, restore service after outages)
- Reduce electricity use and cost (increase off peak pumping and treatment, leak detection)
- Provide increase customer support and involvement (web access)
- Reduce chemical use (predict changes in water use and timing)
- Monitor compliance with watering restrictions/conservation programs
- Increase theft detection
- Remote turn-off/on

Figure 63: AMI/AMR UFM METERS

6.6.1.4 Source & Transmission line Metering

Further reference to the As-Is situation of LMC water supply system, it is strongly recommended to establish metering system in the Transmission and Production lines, since to monitor the actual water in to supply to the system as well as to monitor the pressure variations in real time based. Also, LMC utilizing about 708 Nos of tube well/bore well to full fill the water demand, hence it is recommended to install meters to account the actual production cost in case LMC unable to avoid the ground water source for water supply. For measurement of flow globally In-line Electromagnetic flow meters are being used due to the accuracy of the meters also non-movable parts of the meters. The examples of some Electromagnetic flow meters showed as below.

Figure 64: Electromagnetic Flow Meters (left) and Transmitters (right)

6.6.1.5 Finalization of DMA Boundary and DMA establishment with DMA metering

Lucknow water supply system is the largest distribution pipe network, overall 350 Sq. Km areas out of which 71% area has been covered by LMC water distribution network which was spread throughout entire city in a hydraulically disorganized manner. Also, water is often provided by more than one source. At present LMC utilizing ground water also along with surface water to fulfil the demand. In this type of systems pipes of network are interlinked, then water from surface and ground water sources is mixing up due to this there will be a continual change in system pressure as well as quality of water. However, reduction of NRE requires knowledge of the precise location where water losses occur; therefore, it is difficult task to pinpoint the water loss area in large networks. Hence the Lucknow water supply system needs to divide in to number of small systems that is DMA (District metered area),

During DMA boundary finalization the following activities must be carried out such as,

Pressure Zero Tests, Temporary Flow & Pressure Measurement, Survey of Existing Water Supply System, with this activity, the boundary of DMA can be finalized. Also boundary valve to be identified and must be closed permanently or the link to be disconnected. After finalization of DMA boundary inlet and out let DM (district meter) to be installed as per the requirement along the pipelines. It is recommended to use EMF (Electromagnetic flow meter) with related accessories such as air valves, sluice valves etc.

6.6.1.6 SCADA – Online monitoring system

A Supervisory Control and Data Acquisition (SCADA) system relies on process monitoring sensors to convert physical phenomena (pressure & flow rate) in to electronic signal that can be integrated by the control system. The operator interfaces that enable monitoring and the issuing of process commands, such as controller set point changes, are handled through the SCADA supervisory computer system. However, the real-time control logic or controller calculations are performed by networked modules which connect to the field sensors and actuators.

As of now, there is no online water quality control, flow and pressure monitoring of WTP and ESR/GSR along with production-transmission lines in Lucknow. A quality transmitter such as pH and turbidity transmitters, residual chlorine transmitters and pressure transmitters needs to be installed along the WTP and will be monitored real time to improve the quality of water which will increase the customer satisfaction and sustainability. SCADA system will enable integrated one stop solution for monitoring and control all the flow measurements, pressure readings, etc.

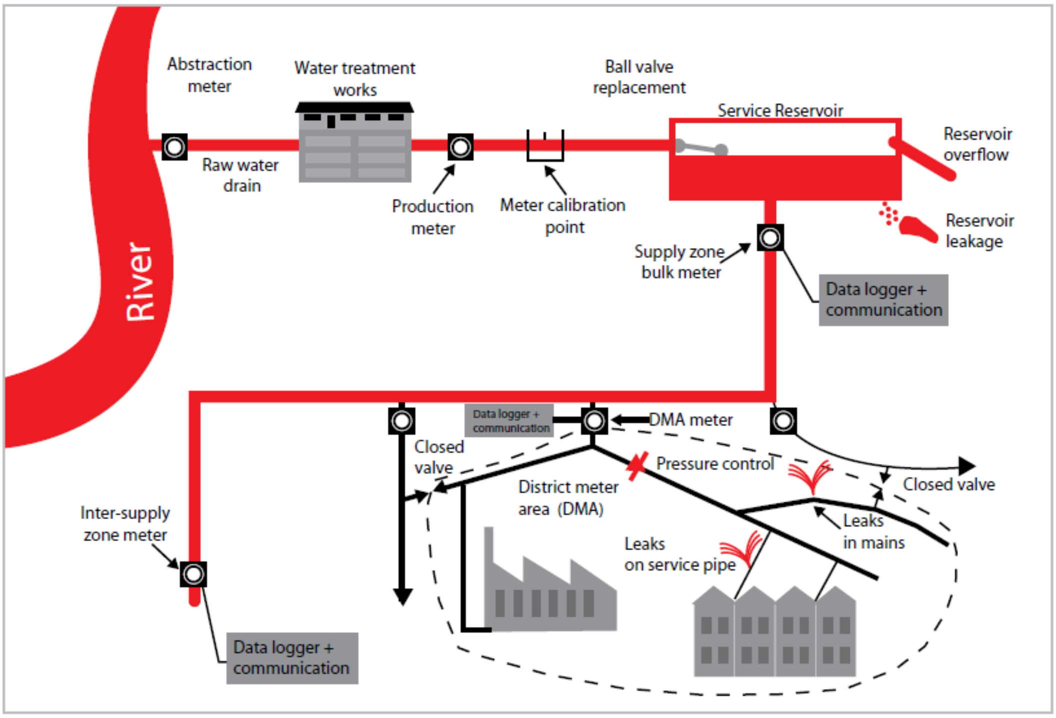


Figure 65: SCADA architecture

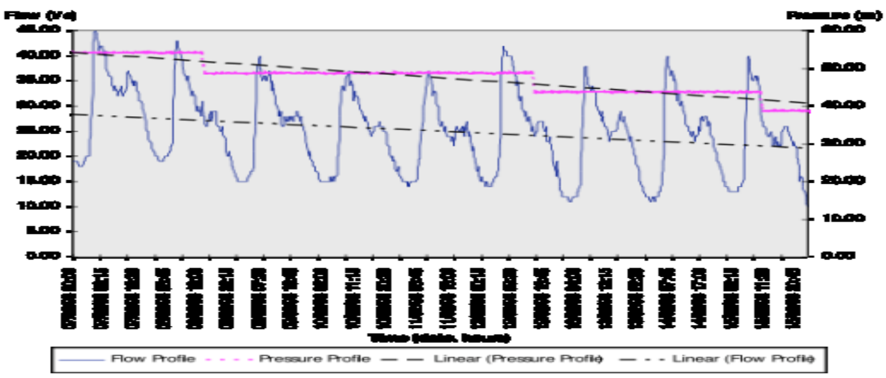


Figure 66: Typical Flow and Pressure Data

6.6.2 Smart water management, real time network optimization and Integration with SCADA:

6.6.2.1 Need of Smart water management

50% of world population is going to be under high water scarcity according to World Water Development (UN) report. Countries of Africa and Asia like Cambodia, Bangladesh, China, and India who is still developing are likely to face water scarcity more. It was expected that till 2050, 70% of population will leave in city of India. With shrinking of water reservoir, low rainfall, etc is hard to feed and provide resources like water, electricity to such high population. Using sensor, Information and communication Technology (ICT) water resources can be managed and be saved for future use. Sensors provide real time monitoring of hydraulic data with automated control and alarming in case of events such as water leakages etc. Analysis of data will help in taking meaningful actions. Smart water system provides reduced water non-renewable water losses and reduced water consumption in field of agriculture.

Pressure plays an important role so controlling pressure also reduces the NRW losses. Real time monitoring network can be employed for detection of NRW losses and manage it. Commercial loss can be reducing by identifying out the illegal connections that is using water supply. Smart meters can play important role to reduce NRW losses. Flexibility and services will improve. Lack of skill labors and not able to understand the depth of problem. To deal with NRW team of skill labors required. There is lack of monitoring devices which will help in understanding the depth of NRW losses. There is also no standard is available for NRW losses like how much is NRW losses per hour, per liter, per house.

6.6.2.2 Application of smart water management in distribution network

An optimization model helps optimize the real time data received from all the transmitters along the water supply system. It enables an advanced level of modelling process for entire water supply system and for effective leakage management and control. Also, recent days advanced real-time network optimization tools are discovered. This will collect all the real-time date from flow meters, pressure loggers, transmitters etc, and the same data will be simulated by the software and it provides the optimized network model. This optimized model results can be applied for number of purposes such as,

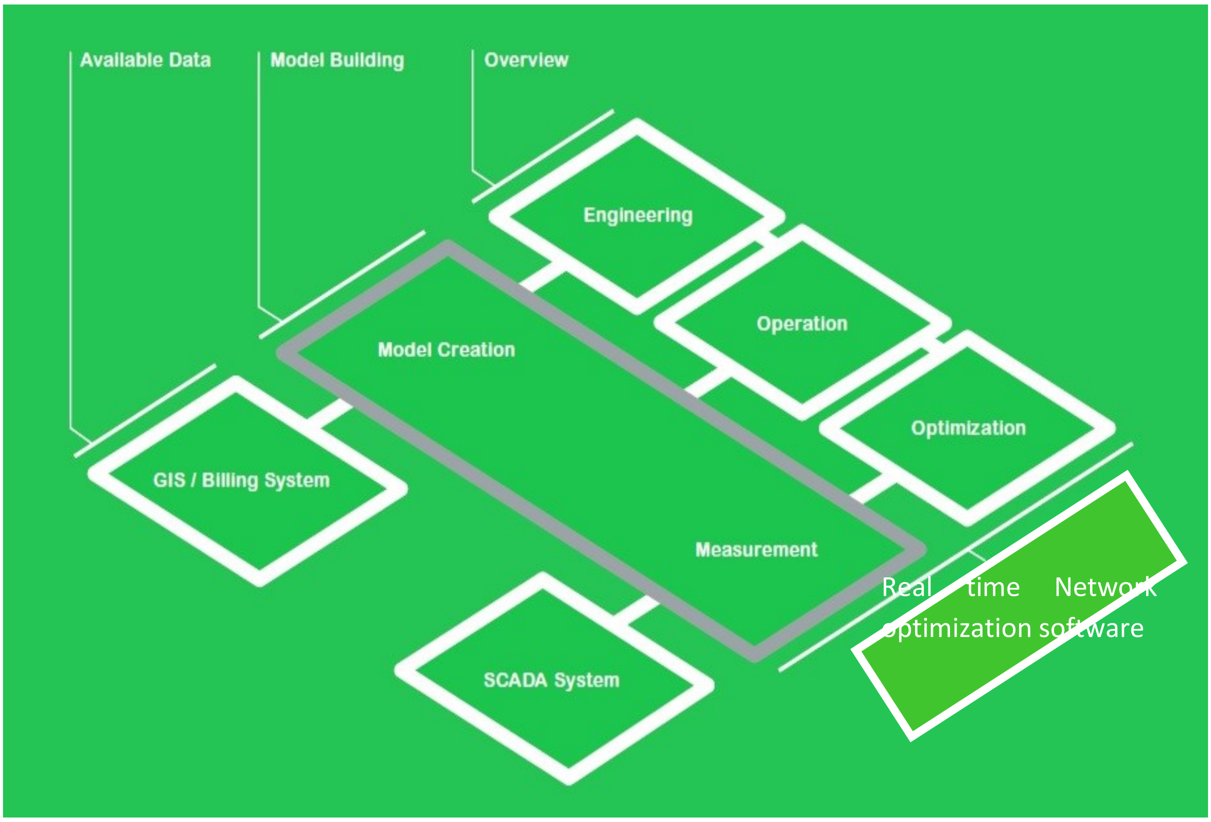


Figure 67: Flow chart represents the application software

It is a hydraulic modelling tool which simulates the flow and pressure in water supply distribution network. This will use real-time data to analyse and track the current situation, enabling operators to make better and smarter decisions to optimize production and enhance economic performance.

Also this software helps to maintain the desired water quality, it tracks the water through its entire network and gives an at-a-glance overview of the chemical composition, age, taste and odour.

6.6.2.3 How does it work?

An intuitive button interface lets you scroll back and forth to obtain data for pressure, flow and water quality at any given time – in the past, now or in the future, anywhere in the network.

Real-time data from the SCADA system is fed into the model. It's possible to combine this with weather forecast data. It will predict future consumption – even during periods of changeable or extreme weather conditions.

It allows viewing different areas, sections, zones and even details of the network. It can easily simulate interventions such as opening or closing of valves, or starting or stopping of pumps, and assess their impact on consumer supply. This can be help full guide the leakage prone area. Optimization of system pressure, the system pressure can be optimized by placing PRV's such that resulting leakage can minimize.

Figure 68: Snapshot of Real Time Network Optimization

6.6.2.4 Approach and Methodology:

The SWMS comprises the following modules.

a) Water Transmission

b) Water Treatment System to ensure Water Quality

c) Water Distribution System

d) Energy Efficiency

e) Asset Management System

f) Geographical Information System

g) Mobile Interface

h) Analytics Reporting

The above software modules need to be tightly integrated into application. This system needs to be integrated with data from SCADA sites, which gives it the capability to effectively manage and administer water operations across the city and enable LMC users to access this information for decision-making.

6.6.2.5 Major Inputs Required for SWMS:

a) GIS data.

b) Details of Water supply scheme from Source to ESR's and distribution network along with all attribute data.

c) Hydraulic model.

d) Elevation data from source to distribution network integrated with GIS Shape file on start and end nodes and levels of service reservoirs (ESRs/GSRs).

e) Existing consumer data / proposed consumer data integrated with GIS shape file.

f) Residential and Non-residential demand of design stages

g) Details of all service reservoirs and sumps.

h) Data of all pumps: BHP, Head, Discharge, Pump curve, and RPM (rotation per minutes).

i) P & I schematic diagram.

6.6.2.6 Solution and Integration of SWMC in Lucknow:

The solution for LMC Smart Water Management System. The software platform should comprise of following modules.

- Master Platform
- Operators platform
- Pump & Reservoir Optimizer
- Pressure Optimizer
- Transmission Line Leak detection

- Geographical Information System
- Asset Management System
- Integration of Existing Water Billing software.

6.6.2.7 System Platform:

The scalable platform for Supervisory, SCADA, MES and IIoT applications that integrates the process with the Enterprise. System Platform provides a collaborative, standards-based foundation that unifies people, processes and assets for continuous operational improvement and real-time decision support.

6.6.2.8 System Platform Key Value Drivers

- Unparalleled Engineering Simplicity
- Unmatched Operational Agility
- Real-time Actionable Intelligence
- Lowest Total Cost of Ownership
- Enterprise-wide Standards Compliance
- Continuous Process Improvement

The System Platform provides common services such as; configuration, deployment, communication, security, data connectivity, people collaboration, and many others. These services allow to build a single, unified "Plant Model" that logically represents the processes, physical equipment and industrial systems, even legacy systems, making the design and maintenance of these systems more efficient, more flexible and with less risk.

The object-based application development environment provided by System Platform enables to build, test, deploy and maintain a wide range of industrial applications using re-usable application objects. The object approach, coupled with application services, enables the user to add functional capabilities, typically found in point solutions, directly to the supervisory/HMI system.

6.6.2.9 Smart Decisions, Anywhere, Anytime, Any Device

Imagine having access to your most important plant poor data from anywhere, at any time, using your mobile smart phone or tablet. Not browser based reports with their inherent delays and viewing problems, but a native phone application that presents your data in a format you can easily read and manipulate using your phone or tablet's native screen and touch navigation features.

6.6.2.10 Integrated Smart Water Management System (SWMS)

Without intelligence about operational performance, network status, and customer demand, water utilities face the challenge of reacting swiftly to any change in these conditions.

It is an operation system that expands your water distribution network SCADA capabilities. It forecasts the behaviour of the distribution network and anticipates the impact of planned and unplanned events before they happen. By using real time data, it takes into consideration the ever changing condition of the network, so the actions are always based on the most updated situation.

In doing this, it also enables water distribution network operators and managers to make better and smarter decisions faster, reduce the risk and cost of operation and maintenance activities. It reduces operation and energy costs associated with water distribution activities by providing operators with information about the impact of planned and unplanned events, even before they happen, through real-time network behaviour forecasting capabilities.

6.6.2.11 The Benefits of the system is:

- Better overview and improved operations of the network.
- Reduces operation & maintenance risks and costs. Predict the network behaviour and see what will happen before it occurs.
- Reduces energy use and cost while ensuring a high level of service.
- Critical event response: Identify the impact of unexpected events and act on them in minutes.
- Improves service and planning. Plan ahead, save time and money.
- Builds on your existing data and IT. Gives existing software systems (SCADA, GIS, hydraulic models, etc.) new functionalities.
- Easy to use: No in-depth hydraulic knowledge needed

  It shall offer an off-line platform as well as a real-time (On line) platform that can be modified and customized to each group of users in a water utility. The user interface can easily be customized to reflect the qualifications and information requirement of each user whether it be:

  - Operator
  - Man in the field

- Planner
- Specialist
- Maintenance staff
- Helpdesk
- Management
- Consumers

6.6.2.12 Model Building

Model building shall be automatic using a Model Manager importing and building the model from the following data:

- GIS/mapping data
- Demand data/profiles/geocoding
- Elevation data
- Calibration data – pressure, flow, level and water quality

The model shall be automatically updated and maintained in Model Manager.

6.6.2.13 Network Analysis

The water network management platform shall be able to perform feasibility studies and scenarios to evaluate the effect of:

- New residential areas
- New industrial sites
- Increased demands
- Maintenance and rehabilitation jobs
- Fluctuations in consumption

This is to design the network to meet future demand or to comply with regulations while improving service, and to avoid bottlenecks and optimize your investment.

A Hydraulic analysis shall allow you to quickly evaluate the effects of modelling changes. Dynamic network elements such as valves, pumps and reservoirs are colour coded to reflect current operational status. Pressure prediction allows you to identify how to operate the network at exactly the necessary operating pressure. In this way, you will be able to reduce the effect of existing leaks.

Water Quality analysis shall allow you to quickly evaluate how various operating conditions Influence water quality. Common water quality problems such as taste and odour can be tracked down using the age-of-water model.

Water Quality can be used to determine mean, true, and maximum water ages. You can also use the water quality module to track any pollutant in the system, and to separate the zones to avoid spreading of the pollutant.

Network Management – Real-time Application The water network management system shall provide a better overview and improved operation by running the water network modelling tool in real-time mode.

By using live SCADA data the model shall be transformed from a planning tool to a decision making tool, integrated in your day-to-day operations – with instant and clearly identified benefits and economic advantages.

The SCADA data shall be automatically loaded into the model, after having been pre-processed and validated to avoid flawed data or replacing faulty instrumentation with emulated values.

The real-time system shall be provided in a graphical user interface that is easy to operate by the operator, but that can also be configured in the same tool to run more complex scenarios requested by the engineer and planner.

The real-time system shall be able to combine historic view, real-time views and predictions in the same user interface – easily accessible.

The operator shall not be required to possess any in-depth knowledge of modelling to use the water management system. By scrolling back and forth on a simple button interface he shall be able to obtain the information he need such as pressure, flow and quality for any given point in time - in the past or in the future.

The model shall be fed with live information from the SCADA system as well as forecast information about weather conditions. This will enable the model to predict future consumption even during periods of quickly changing or extreme weather conditions.

Different variables, such as supply pressure, age of the water, amount of chemicals in the water or flow shall be displayed. Effects of interventions, such as opening or closing of valves shall be easily simulated, to reveal any disturbances in consumer supply.

The information shall be made available to the call centre. Error conditions or temporary problems shall be evident. The call centre shall be able to click on any node in the network to see measurements such as the water pressure at the specific location. Alarm set points for all parameters shall be pre-configurable.

The management system shall be fully integrated with SCADA and shall be prepared to send an alarm to SCADA if error conditions in the network are predicted.

The management system shall be visualized in a control room atmosphere with focus on simplicity and easy access to information – enabling everyone to obtain qualified information about the network – now and in the future.

In the main view it shall be possible to scroll in and out – visualizing what is relevant for the specific water utility; i.e. that GIS data suddenly materializes.

It shall be possible to generate VIEWS for each of the zones that the water utility wishes to focus on. It shall be possible to pre configure the themes the user wishes to see, whether it is related to:

- Pressure
- Flow
- Velocity
- Flow Directions
- Water Quality: Age
- Chlorine concentration
- Water Balance (Water Loss-NRW and Revenue Water)
- Leakage as in Minimum Night Flow (MNF)
- Pipeline Leak Likelihood, Criticality & Replacement prioritization
- Other simulated parameters

Contingency Management – Pollutants The water network management system shall with basis in the real time data be able to perform:

- A trace, performing a forward analysis of a situation from any given time
- A diagnostic trace, performing a backward analysis of a situation from any given time

The trace analysis shall be based on the real-time data, hence done on what actually has occurred. It is not needed to upload the model – it is ready for this analysis right away.

Production Planning This system shall combine the knowledge about the water producers within the network with hydraulic constraints and water supply. Subsequently, the most economical way of operating the utility shall be identified leading to significant cost reductions.

Leakage management to ensure that you will quickly detect new leaks in your network, the system shall provide a leak detection system integrating the Integrated Flow Measurement (IFM) and Nightline Measurement (NLM) philosophies. These two methods shall be directly linked to the SCADA data. Zones with leaks are identified by the leak detection system, and an alarm shall be forwarded to the SCADA system to make sure that proper action is taken immediately.

a. Optimization Modules:

The water network management system shall be able to include optimization modules such as:

- Pressure Optimization
- Pump and Reservoir Optimization

b. Transmission/Trunk Line Module:

- Leak Detection and Location for Trunk lines

The water network management system should be equipped with a pressure optimization that utilizes the real-time hydraulic model for set-point generation.

Reduces electricity consumption and CO2 emission with 10-15% Secures stable operation with sufficient pressure to prepare the model.

This ensures:

- Optimization using fluctuating electricity prices
- Correct calculation of required flow to network
- Correct calculation of network capacities and reservoir flexibilities, ensuring required minimum pressures
- Easy, quick and affordable start-

c. Pressure Optimization module

It takes into account the fluctuation of consumption in the net, and automatically provides the set-points for the pumps or pressure control valves ensuring a supply pressure that is ‘just’ good enough. It provides operational stability and cost savings

The automatic Pressure Optimization will according to experience reduce your leakage level with approximately 10-15%, reducing your water loss, and associated cost of production and chemical treatment, but also reducing the pumping cost and subsequent CO2 emission. The module requires limited or no operation. Training in operating the system is not required. The module is in operation around the clock. Save money all the time – every single day of the year.

The automatic Pressure optimization module uses SCADA data from the water distribution network, creating the best possible basis for optimization. It takes into account the common operational changes, such as valves being opened or closed, large consumers with varying consumption, and variation at weekends and holidays.

Unusual operational interruptions will also be included in the calculation, giving you the right picture of the operation all the time. Pressure Optimization utilizes consumption data based, for instance, on time and type dependent profiles or demand forecasts.

Implementation of the automatic Pressure Optimization requires no knowledge about the operation. The Real-Time functionality can be added, enabling a full and dynamical presentation of pressure, consumption and flow in the network. This gives you the perfect overview and tells you a lot about the operation of your network. The Real-Time functionality can also be utilized to send calculated data into the SCADA system. This expands the overview and may postpone or eliminate the requirement for adding new, costly measurement points.

In water distribution systems, the pumping costs often constitute the major part of the operating costs. In order to minimize the pumping costs an Add On Pump and Reservoir Optimization module should be included.

The Pump and Reservoir Optimization module enables you to determine the optimal pumping schedule for a pipeline system for a given period of time (user defined), while taking the following points into account:

- Demand schedules
- Storage capacities of reservoirs
- Power costs (unit costs may vary over time)
- Time dependent pressure constraints
- Capacity and availability of pumps and other equipment

Leakage Management runs a dynamic real-time simulation model to generate leak responses. This means that your Leakage Management System will work under all operating conditions, including periods with starting and stopping of pumps, opening and closing of valves, etc.

The following leak responses can be generated:

- Unexpected flow (UF).
- Unexpected pressure (UP).
- Mass volume balance (MVB).

Leakage Management may either be embedded as a component in the SCADA system, or you may implement it as a stand-alone system with a data communication interface to the SCADA system or directly to the PLC's (Programmable Logic Controller).

Leakage Detection and Management has a user-friendly interface enabling easy access to most modern SCADA systems.

To ensure a robust leak detection system that uses all currently available information and is always in operation, the interface module provides you with a number of customizable options for checking incoming measurements and emulating missing or faulty data. Furthermore, you have access to straightforward configuration of the system and clear presentation of results via the comprehensive graphical user interface.

Leak alarms are stored in the Leakage Management event log, or they may be transferred to the SCADA system by means of the Leakage Management - SCADA inter communication. User-friendly interface enables easy access to most (modern) SCADA system

6.6.2.14 The Hydraulic Model

A Master Model (unique file) should be created and configured, so that it can be used for Offline purposes (by creating copies of the master file and working offline) and for Online purposes (the master is running automatically on the server 24/7).

The model will be built based on the information supplied by client:

- GIS information,
- Billing data,
- Consumer profiles

6.6.2.15 Operational data

The model will run in real-time (cyclic) mode, for a time step that is configurable by the user: i.e. every 30minutes. Hydraulic results are generated for the current state of the model (boundary conditions loaded from SCADA). Simulated results generated from the cyclic calculation will be stored in the internal memory for direct and quick access. The number of hours to be stored is configurable by the user: i.e. last 24h.

From an Operator station, the user will be able to run the real-time model to reproduce a past situation: re-run simulations using historic data as long as they are stored in the Data Manager database (for more details, please consult *Section* of this document). In addition, the user will be able to simulate any changes to the current network operation under the context of "*What-If*" scenario analysis.

The hydraulic model will be initially calibrated based on measurements from SCADA. The parameters to be fine-tuned in the model to mimic SCADA results are usually reduced to elevation and pipe roughness. It is important to clarify that calibration is directly related to the quality of the data used to build the model: the higher the accuracy and precision of the data to be imported, the better the results obtained.

In the real-time operation mode, the model is automatically adjusting demands in every Flow Control Zones (FCZs, equivalent to DMAs) by using the current SCADA flow measurements. Therefore, the zone flow is automatically adjusted in every simulation.

6.6.2.16 Smart water management in water treatment plants

High infrastructure is required to provide water services from door to door in cities. Maintaining such infrastructure having challenges like linkages, purity of water etc. It is important to maintain the quality of water from source to tap hence real time surveillance is required. Water contamination causes diseases like cholera, hence there is need to identify harmful components present in water. Water treatment plan (WTP) provide clean water supply to the city or locality but consume high energy and have large carbon foot print. High monitoring is requiring for proper functioning of plant. Development of ICT devices makes online monitoring possible by optimizing device utilization with real time alarming.

The data will be monitored with help of quality & operational sensors/transmitters such as PH transmitter, Residual chlorine transmitter, Turbidity transmitter, Level transmitters, vibration system etc. The data form the transmitter will be integrated with the centralized software, which provide the alarm based on real timing data.

6.6.2.17 Asset Management System

Enterprise asset management is not a "one-solution-fits-all" proposition. Organizations have different needs, drivers, technical requirements, and circumstances, which require different solutions. The right plan is the strategy that is tailored to meet specific needs and leverages utility's existing strengths. And the right plan can deliver significant benefits, namely, a better understanding of existing assets and the ability to use and manage these assets to:

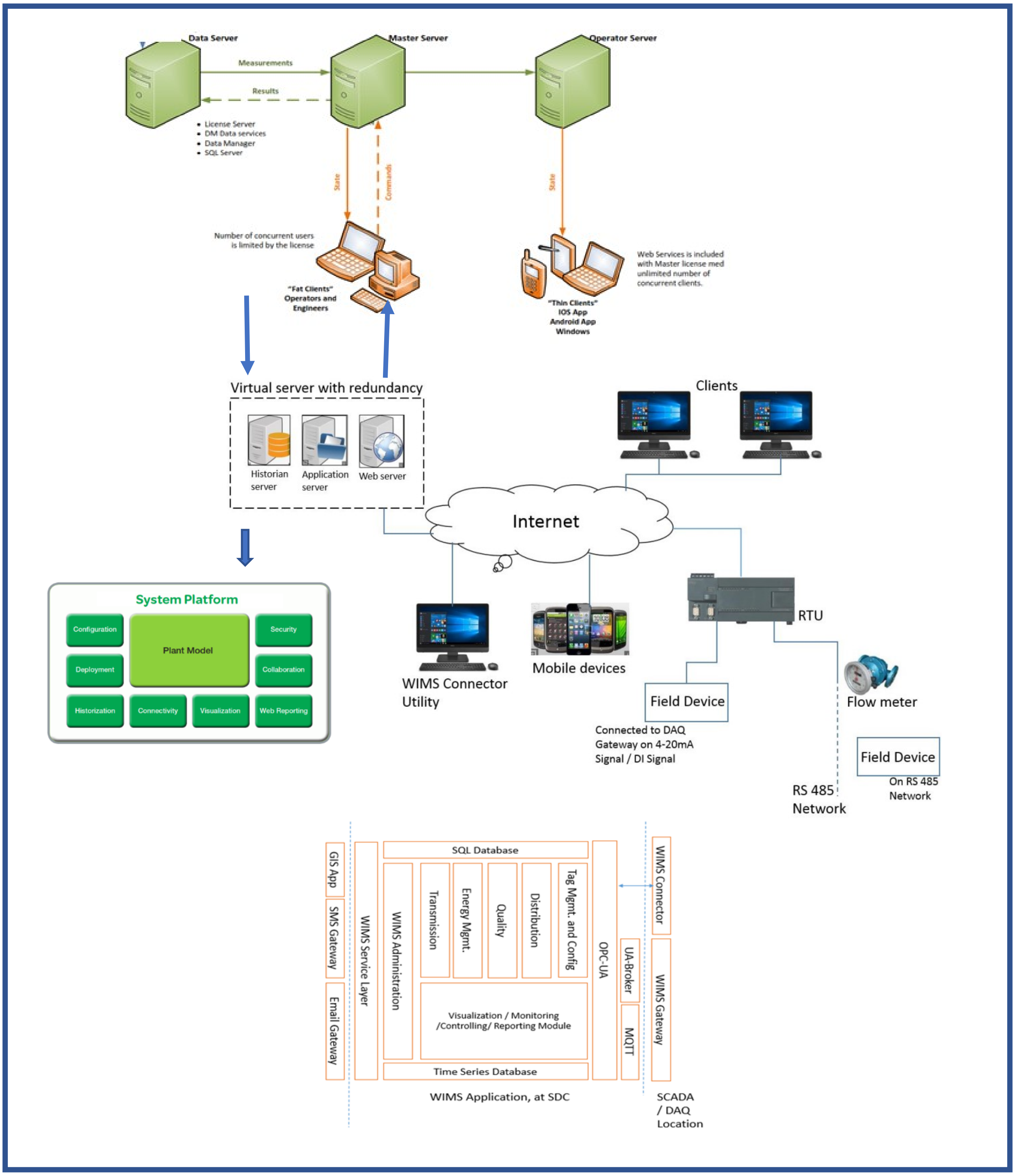
- Increase capability and transparency throughout your organization
- Improve process efficiency, workflows, practices, and services
- Better understand the condition of your assets and improve the integrity of your asset data
- Develop performance measures and practices that promote continuous improvement
- Make sound, data-driven business decisions
- Develop growth, forecasting, and CIP strategies based on reliable work, asset, and performance data
- Build stronger maintenance strategies and practices

The system will comprise of the below features:

- Tracking financial and inventory details of hardware, software and virtual infrastructure - as well as non-IT assets - through their lifecycle.
- Asset requisition to provisioning- (Workflow for approvals, validate entitlement, issues chargebacks, provision services)
- Asset maintenance module
- Creation of asset types - Set high and low thresholds, severity for each asset (multiple allowed based on time of day)
- Alert generation and sending based on thresholds
- Dashboard to show alerts
- Integration with software events correlation / workflows / rules engine
- Define triggers based on specific assets, asset types, asset groups and asset attributes

- Associate assets with other assets
- Integration with GIS
- Import asset using excel based on asset type
- Mapping of GIS locations of all new servers, meters, sensors, UPS, etc.) Installed during the project period.

6.6.2.18 SWMS Architecture



6.6.2.19 Benefits of Smart Water Management System

- Enhances real-time supervision in SCADA.
- Transforms network management approach from reactive to proactive.
- Better overview and improved operations of the network.
- Reduces operation & maintenance risks and costs.
- Reduces energy use and cost while ensuring a high level of service.
- Improves service and planning. Plan ahead, save time and money.
- Uniform distribution of water.
- Reduces the risks of levels of service breaches (outages, low pressure and water quality issues).
- View at a glance the current levels of services (outage, pressure, water quality) in the distribution network zones.
- Check the status of all the storage points (reservoirs) and their trends over the last 24 hours.
- Visualize on thematic maps the current network performance.
- Analyze a complete set of KPIs on energy usage, network pressure conditions and water quality to identify room for improvement.
- Evaluate the performance of all pumping stations serving the distribution network to prioritize interventions for cost saving.
- Possibility to anticipate what will happen in the distribution network over the next 48 hours
- View at a glance what distribution network zones and customers are likely to experience disruptions over the next 48 hours.
- Evaluate the impact of planned maintenance on levels of service.
- Notify genuine issues to the staff in charge of the zone/asset where the problem is located. Connect to a What If scenario, allowing the operator to run various configurations without jeopardizing a running production cycle.
- Analyze in detail the behavior of a specific zone over the last 24 hours.
- Be presented with active alarms & focus on a specific zone &/or time period &/or alert type.
- Be alerted on forecasted issues before they actually happen.
- Be informed on data anomalies when measured and simulated data considerably differ.
- Access additional contextual information including trends and maps to obtain a better understanding of zone or asset behavior.
- Man power usage is reduced for data
  Collection and accurate data availability.
- Raise a workflow notification from the SCADA.
- Visualize thematic maps and dashboards.
- Display reports.

6.6.2.20 Smart Water Billing System (SWBS)

Commercial losses, sometimes called as apparent losses include water that is consumed but not paid for by the consumer. This leads to loss in revenue for the utility as the cost of production is already incurred whereas no collection done against that consumption.

Commercial loss reduction can be accomplished in lesser time than physical loss correction and recovery. The impact can thus be higher with quicker return on investment. It is always advisable hence, to focus on commercial losses in the initial phase of NRW reduction.

6.6.2.21 Why SWBs?

SWBS will send the monthly water meter readings corresponding to the user's water consumption to the water company wirelessly. The consumer side meters will be indoor meters for each apartment for protection and safety. Once the water consumption is received by the water company, an acknowledgement will be sent to the user as an SMS notification and then saved in the data base of the water electronic water meter has a water flow sensor used to sense the flow of water, then this value is taken by the microcontroller to compute its equivalent water consumption volume. The total water consumption displays continuously on the LCD, while the monthly water consumption is sent wirelessly to the base station using a GSM signal. The receiving mobile phone at the base station receives the monthly consumption. The worker at the base station selects an automatic program that is specially designed to save these values automatically to a database. Then, the values are uploaded to the designed website and bills are created automatically and sent to the user through email without interference of any employees, where it can be paid online.

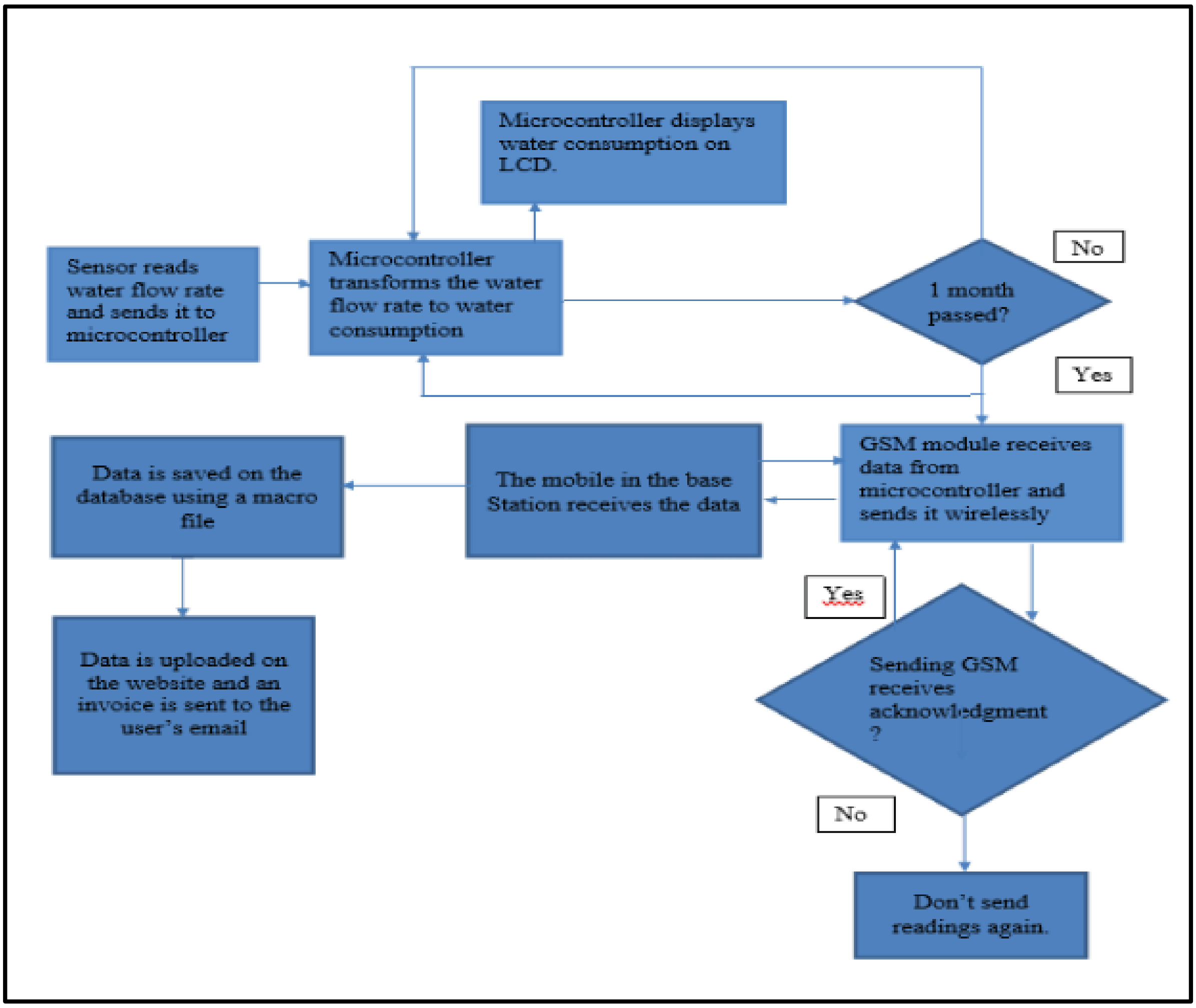


Figure 69: Flow Chart of Smart Water Billing System

Above mentioned flow chart is based on incorporation with AMI/AMR meters.

6.6.2.22 Components of SWBS:

- Software for billing

Nowadays, there is cloud based water billing software used by cities. The complete utility billing toolkit offers a flexible solution for governments looking to both increase their efficiency and simplify their workflow.

Many governments are stuck using outdated water billing software, suffering every day from a lack of features yet unable to upgrade. The standard features of the software include meter integration, eBilling, a customer portal, and details on meter records, owner and tenant account, etc. Water billing thus becomes as easy as uploading a meter file, clicking a few buttons, and printing out bills.

- POS device

POS devices are handheld computers for meter reading. The devices can be programmable and used for setting specific number of consumers to be read. For example, the zone has 2000 connections. The device can be programmed to read 100 connections a day, thus, needing total of 20 days for completing the activity. The 100 connections to be read in a day will also be set so that readings for those 100 must be taken on the same day. If the executive fails to complete reading for those 100 consumers, an explanation needs to be given to the concerned authority.

Figure 70: POS Devices for Meter Reading

- Consumer App

The system will have a mobile application which will be easy to use to consumers to have their information about consumption added. The consumers can also check historical consumption and understand highs and lows as observed in their data. This will give transparency to the consumers and enable them to monitor and check their consumption.

Figure 71: Consumer App

- Centralized Data analytics software

The utility needs to have software for centralized data management and analytics. This will use water utility and external data to generate water use and customer insights. Using advanced technology solutions, water utilities can better communicate with their consumers about the value of water, how their water use compares to others, and how they can save money. This suite of engagement and analytics tools allow customers to help themselves by accessing detailed information to answer questions and solve common problems. These capabilities translate into significant cost savings for utilities, help protect revenue, and create dramatic improvements in customer satisfaction levels. This all contributes to more resilient water systems that benefit customers, the communities they live in, and the environment.

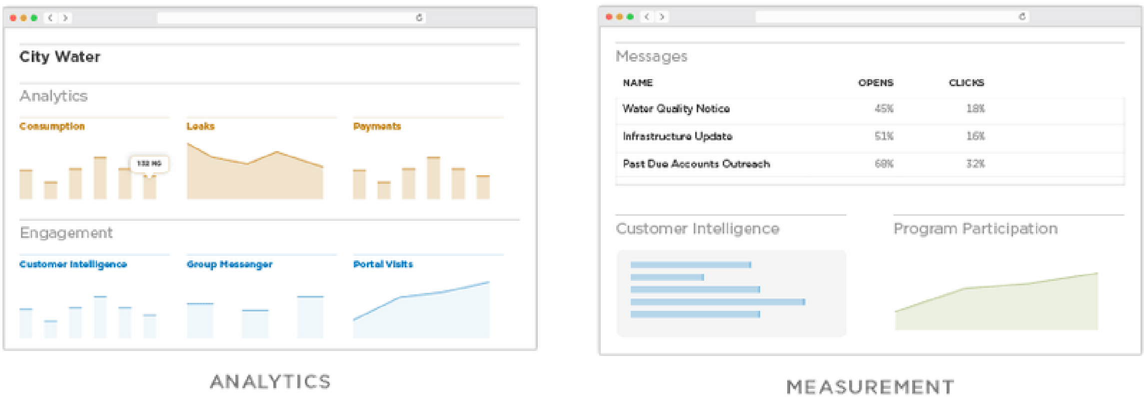


Figure 72: Centralized Data Analytics Software Snapshot

- Online and physical one stop office for payment collection of all utilities

There is a need for one place solution for payment of all utilities. An excellent example for this is Bangalore One – One Stop Non-Stop Service. Bangalore One project is to provide various citizen centric services across multiple domains through a single point of access located across the city of Bangalore. It renders one-stop services to the public eventually through multiple delivery channels like ICSCs and Bangalore One Portal. The Citizen's interaction with the Government Departments will be under a single umbrella. These services are incorporated under the Government to Citizen (G2C) facilities provided by the Government of Karnataka.

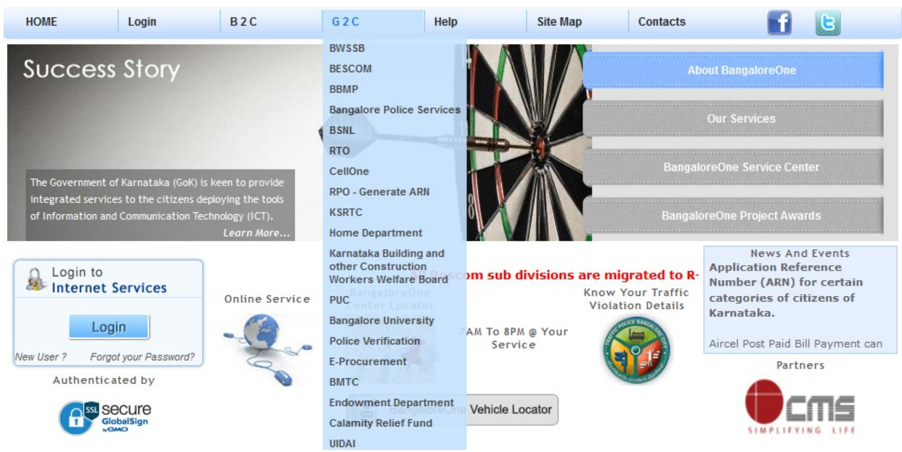


Figure 73: Bangalore One Website

6.6.2.23 Benefits of using SWBS

- Data Analytics

Sudden spikes or irregularities in the meter readings will be programmed to raise alarms. The utility's team will analyse the issue and find out possible errors like bypassing of meter, meter errors, etc. This will help in quick identification of the problem and correction.

- Consumption Accounting Error:

Executive taking meter reading on monthly basis, will reach say, 60 houses on day 1. Next 60-70 houses, he will be able to cover on day 2, next on day 3, etc. This will also have public holidays and weekend in between. Thus, the readings will be scattered and not uniform for every consumer and will also give chance to human error intervention. But, the billing department will process the reading and raise billing for the entire month without considering the difference in days due to the meter reader. This will affect the billing cycle and an effective way to solve this is implementing SWBS which helps in taking real time readings at specified time for all consumers thus promoting equitable water charges.

6.7 Implementation of NRW reduction activities (POST-FEED 2): `

The activities involved in Post-Feed -2 described in this section. It is being recommended to estimate the cost and quantity of Post-Feed 2 activities based on results from FEED, due to lack of basic database of LMC water supply system. However further instruction from MoUD we have derived the quantity with global industries practices and experience, also the quantity has been validated by LMC. In this report we haven't analysed the new augmentation cost of.

6.7.1 Mandatory Works:

Mandatory works are the activities which involve Rehabilitation and replacement of assets,

Rehabilitation / replacement of assets involves below activities for the entire water distribution network,

- Replacement of all existing PVC/AC pipelines,
- Smaller diameter pipeline (less than 100 mm diameter),
- Replacement of aged and corroded pipeline, along with associated house service connection and valves.
- Replacement of corroded house service connection.
- Capacity augmentation (even though it is not a part of NRW reduction), the augmentation work can be carried out for strengthening network based on future demand.

Since the life time of PVC and AC pipes are very less also those pipes can be easily gets damaged by even minimum external forces also. Also, it is difficult to obtain the permanent solution by rectify the PVC/AC pipes due to the material characteristic of the pipes. Hence it is recommended to replace such PVC/AC material pipes with DI (Ductile Iron pipes).

In general, it was observed that at Lucknow, extension of distribution network for new consumer connection has not been done with proper hydraulic model, there may be the chance of usage of less than 100 mm diameter pipelines for network extension, it may be one of the root cause for huge head loss due to increase in demand or tuberculation and encrustation of scales inside the pipeline. Hence it is recommended to replace entire pipelines which are less than 100 mm diameter with suitable diameter of DI pipelines based on the results from hydraulic model. However, inside the distribution network like dead end, network loops the smaller size diameter can be replaced with 100 mm diameter DI pipeline. As per CPHEEO manual the considerable design life of water system is 30 years only. Hence it is recommended to replace the corroded and frequently leaking CI pipeline to achieve and maintain the targeted NRW effectively.

Figure 74: Pipeline snapshot field survey

It is mandatory to replace all the corroded house service connection since leakages in house service connection contributes NRW more since the network length of the house service connection is more than rest of the pipelines, also identification of leakage in house service connection also quite difficult than rest of the higher size pipelines. However open sounding method is one of the good solutions to identify the house service connection leakages. In general, Indian scenario it is advisable to replace the House service connection above 10 years old, since in India in past periods house service connections provided by GI (galvanised iron) pipeline and life time of the GI pipeline is very less, since it will corrode quickly. Also, due to replacement of house service connection the distribution network can identified and permanently disconnect un authorized connection. Hence it is recommended to replace the house service connection with MDPE pipes since MDPE pipes are long lasting and non-degradable.

Further to the survey undertaken along the sample DMA at Lucknow, it was observed more quantity of PVC/AC pipeline along the distribution network. Hence it is strongly recommended to replace the PVC/AC and corroded pipelines to achieve the targeted NRW as well as sustainability. Also, it will improve the customer satisfaction due to improvement in pressure. It was observed LMC having intermittent water supply pattern, since it will lead sedimentation inside the pipe which causes encrustation of scales inside the pipe, which results huge head loss, especially corroded and aged CI pipelines. The below DMA drawing represents the existing condition of LMC water supply system with PVC/AC and CI pipelines also it was observed existence less than 100 mm diameter pipeline. The below DMA maps showing the availability of PVC/AC and lesser diameter pipes along the LMC water distribution network.

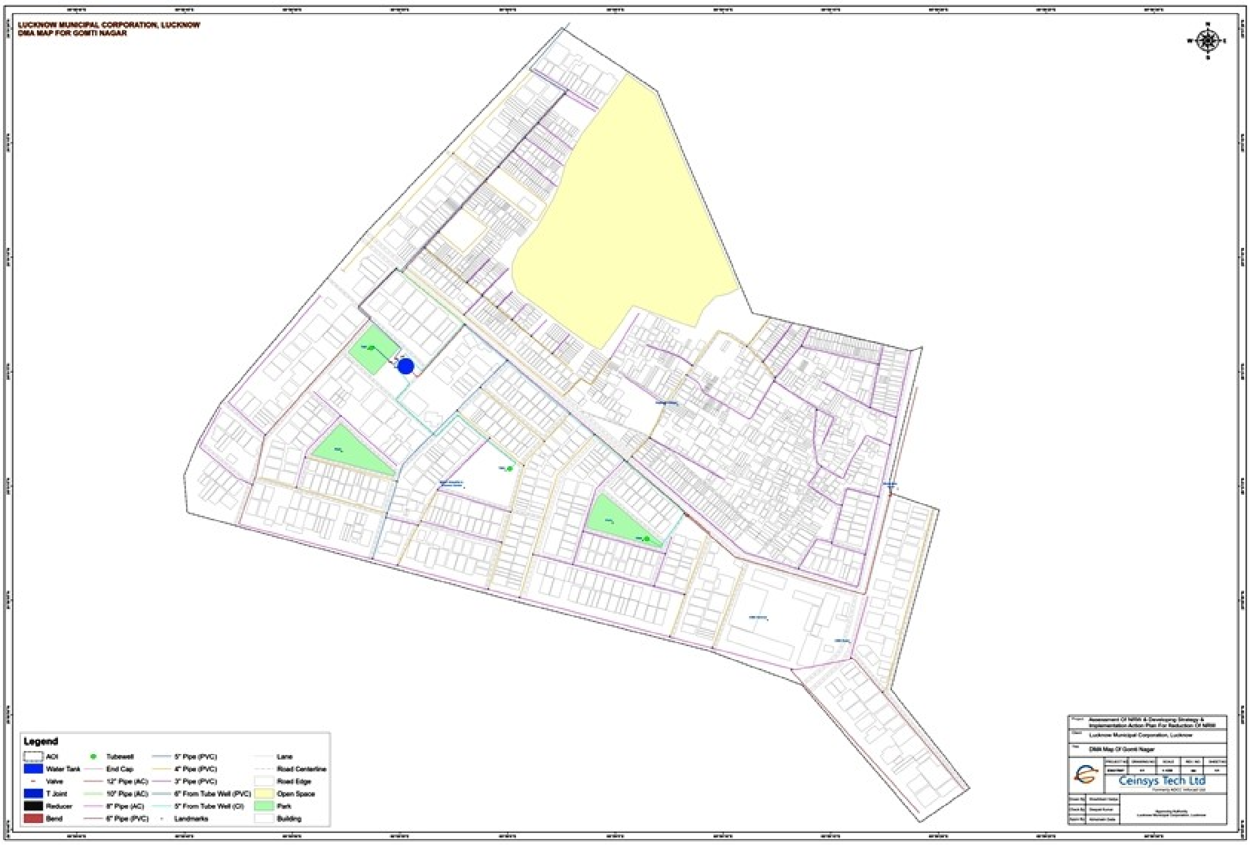


Figure 75 : Updated Goamathi Nagar DMA diagram

6.7.2 Capital works:

Capital works are the works which involve expansion of distribution network, new augmentation for sources, strengthening of distribution/feeder pipeline based on future demand with consideration of increase in population. In Lucknow strengthening work cannot by assumed due to lack of database as already in this report. Hence the strengthening work can be estimate after completion of FEED.

However as per the available report, it was observed that LMC water distribution system covered up by 71.37% only. Hence in this chapter it was assumed capital work with global assumption and extrapolation of vales obtained from sample DMA the pipeline quantity has been assumed to cover the water distribution network 100%.

6.7.3 Leak Detection and Rectification

6.7.3.1 Active leakage control (ALC)

Active leakage control (ALC) is vital to cost-effective and efficient leakage management. The quicker the operator can analyse DMA flow data; the quicker bursts or leaks can be located. This, together with speedy repair, limits the total volume of water lost.

6.7.3.2 Regular survey

Regular survey is a method of starting at one end of the distribution system and proceeding to the other, using one of the following techniques:

- Listening for leaks on pipework and fittings
- Reading metered flows into temporarily zoned areas to identify high-volume night flows
- Using clusters of noise loggers

6.7.3.3 Leakage monitoring

Leakage monitoring is flow monitoring into zones or district metered areas (DMAs) to quantify leakage and to prioritize leak detection activities. This has now become one of the most cost-effective activities (and the one most widely practiced) to reduce real losses. The most appropriate leakage control policy for a utility will mainly be dictated by the characteristics of the network and local conditions, which may include financial constraints on equipment and other resources.

It is a methodology which can be applied to all networks. Even in systems with supply deficiencies, leakage monitoring zones can be introduced gradually. One zone at a time is created and leaks detected and repaired, before moving on to create the next zone. This systematic approach gradually improves the hydraulic characteristics of the network and improves supply. Leakage monitoring requires the installation of flow meters at strategic points throughout the distribution system, each meter recording flows into a discrete district which has a defined and permanent boundary. Such a district is called a district metered area (DMA). A leakage monitoring system will comprise a number of DMAs where flow is measured by permanently installed flow meters. The DMA meters are sometimes linked to a central control station via telemetry, so that flow data are continuously recorded.

Analysis of these data, particularly of flow rates during the night, determines whether consumption in any one DMA has progressively and consistently increased, indicating a burst or undetected leakage. It is important to understand the composition of night flow, as this will be made up of customer use as well as losses from the distribution system. DMA maintenance is crucial to maintain the accuracy of the data. It includes maintaining the integrity of the DMA boundary as well as plant and equipment, i.e. it involves checks on the accuracy of meters and secondary instrumentation.

6.7.3.4 Leak localizing and real-time network optimization.

Once the network is divided into DMAs, those showing a greater volume of night flow per connection than the others, can then be inspected more thoroughly by carrying out a leak localizing exercise. Nowadays new software's developed to localizing the leaks prone area by analyse the real-time flow and pressure data of the DMAs. Also, the software can automatically simulate the hydraulic modelling and provides the solution for leak localizing. Also, the recent hydraulic software can identify the leak location in transmission mains also based on difference in pressure.

6.7.3.5 Leak location

Pinpointing of leakage can be carried out by acoustic based equipment. The detailed leak detection equipment explained in Table 42.

6.7.3.6 Identification of Physical losses in transmission mains and water related civil structures.

In general losses in transmission lines and civil structures such as sumps, reservoirs etc. mainly contributed by physical losses only than apparent losses. The physical losses are due to leakages along the pipeline and civil structure also losses due to over flow from reservoirs/sumps and losses due to treatment processes. Further reference to the field survey, it was observed some water leakages along the civil structure and pipe appurtenances. These losses or mainly due to poor maintenance and aging. These types of physical losses can be easily identified and the losses can be avoided in a short time. Hence it is recommended to identify the leakages in the pipelines with smart leak detection techniques such as Gas tracer method, Smart ball system, Leak noise correlator etc.

Figure 76: Leakage in air valve at Balaganj WTP

Figure 77: Leakage in settling tank at Balaganj WTP

Also reservoir leakage can be identified by Drop test. Nowadays new softwares are developed to identify the leakage in transmission line based on difference in pressure. Using this network software's, efficiently monitor and locate the leakage along transmission lines.

The capability of Leakage Management depends on the instrumentation of the pipeline. For state-of-the-art flow meters and pressure transducers, you may consider the following key figures as guidelines:

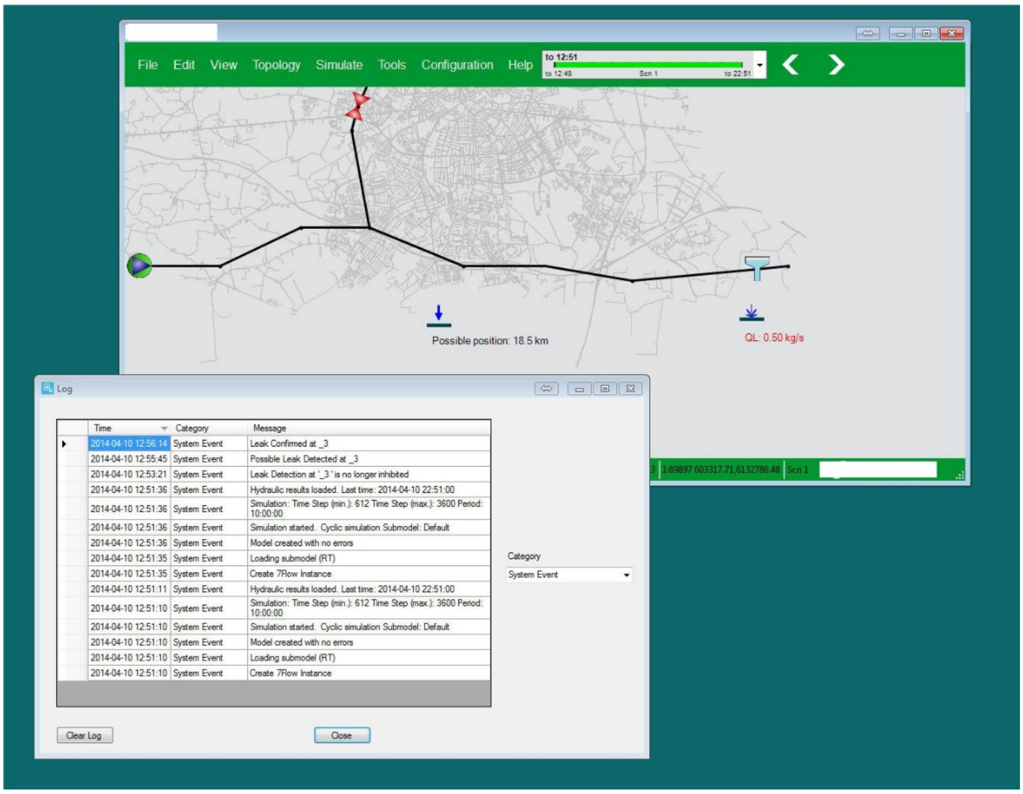


Figure 78: Typical diagram of leak identification software

- Minimum detectable leak size: 0.5-2% of throughput, depending on the pipeline layout, operation and quality of instrumentation.
- Location accuracy: 1-10% of distance between the pressure meters, depending on leak size and flow velocity.

Leakage Management runs a dynamic real-time simulation model to generate leak responses. This means that your Leakage Management System will work under all operating conditions, including periods with starting and stopping of pumps, opening and closing of valves, etc.

The following leak responses can be generated:

- Unexpected flow (UF).
- Unexpected pressure (UP).
- Mass volume balance (MVB).

Leakage Management may either be embedded as a component in the SCADA system, or you may implement it as a stand-alone system with a data communication interface to the SCADA system or directly to the PLC's (Programmable Logic Controller).

Leakage Detection and Management has a user-friendly interface enabling easy access to most modern SCADA systems.

To ensure a robust leak detection system that uses all currently available information and is always in operation, the interface module provides you with a number of customizable options for checking incoming measurements and emulating missing or faulty data. Furthermore, you have access to straightforward configuration of the system and clear presentation of results via the comprehensive graphical user interface.

Leak alarms are stored in the Leakage Management event log, or they may be transferred to the SCADA system by means of the Leakage Management - SCADA inter communication. User-friendly interface enables easy access to most (modern) SCADA system

The below flow chart representing the active leakage control activities.

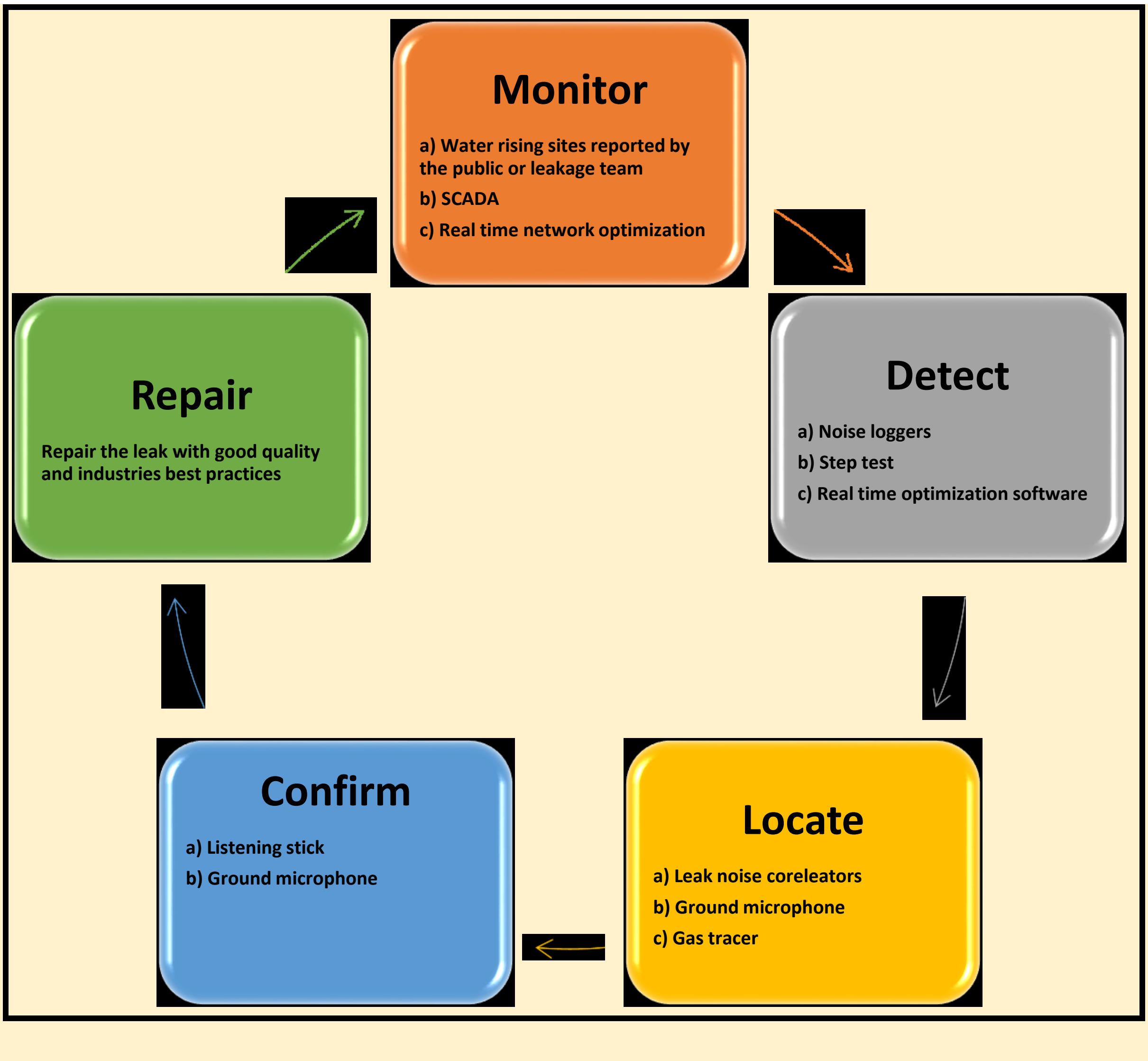


Figure 79: Active Leakage Control.

It is one of the most important responsibilities of a Water Undertaking to properly maintain the transmission and distribution mains in order to prevent waste and provide a constant pressurized flow of potable water to the consumers. It is equally important to prevent damage to the public property which could arise for not properly repairing a defective pipe. Proper planning and implementation of remedial measures will avoid leakages and breakdowns.

6.7.3.7 Note details of existing pipe

The full details of the failed pipe and/or fitting should be noted including material type, approximate age, class and general condition. Reasons for failure should be established as accurately as possible and recorded. Check actual external dimensions of the pipe and determine any tendency to quality for effective repair.

6.7.4 Repair Work:

6.7.4.1 Type of repair–wet or dry

A 'wet' repair is defined as a repair which can be achieved while maintaining a nominal pressure in the pipeline. Split collars or identical fittings can be installed in this way if the conditions are favourable.

A 'dry' repair is defined as one in which the main is completely isolated and drained out. 'Cut out 'repairs necessitating the removal of a section of the pipe and/or joints will require 'dry' main on which to work and the pipeline should be drained out.

6.7.4.2 Extent of repair work and availability of repair fittings and tool

The replacement pipe and/or repair fittings should be selected and their dimensions marked on the pipeline. For a 'dry' repair a final check should be made that all the required fittings and materials are available and are compatible before any attempt to cut the same is made.

6.7.4.3 Bedding material

Assess and make available the bedding material if required.

6.7.4.4 Report to Control

When ready to start repair, inform 'control'.

6.7.4.5 Repair of small, local defects - 'wet repair'

For small local defects such as pinholes a single split collar or wraparound clamp may be all that is required. The repair can be carried out at as a 'wet' or 'dry' operation. In case of 'wet' repair care should be taken to maintain a steady, gentle flow so as not to dislodge the sealing elements.

6.7.4.6 Cut out – 'dry repair'

For a more extensive damage e.g. a longitudinal fracture, a section of pipe is cut out and replaced by the use of two appropriate couplers. If full extent of the fracture is not clearly defined cuts should be made at least 300mm beyond each end of the visible crack or defect and in case of any doubt the full length of damaged pipe should be replaced. This necessitates cutting out the joint at both ends of the affected pipe, thus the repair normally requires two replacement pipe sections and three couplers.

6.7.4.7 Replacement repairs- following observations are important

- Carryout correct measurements and give allowance for expansion;
- All cuts should be made clean and square;
- In A.C. pipes, cuttings should be avoided;
- All cut edges should be prepared (scraped, deburred, chamfered etc.) to the manufacturer's recommendations.
- Both exposed ends of the existing pipe should be similarly treated;
- Couplers should have their sealing rings lubricated if recommended;
- Correct expansion gaps should be allowed;
- Good alignment is essential particularly if narrow couplers are used;
- All couplers and collars should be centralized;
- Tighten all bolts evenly;
- Do not over tighten bolts or compression joints;
- Restore any damaged coatings on the parent pipe;
- Ensure full protection to the bolts and any exposed bare metal before burial.

6.7.4.8 Record of repair

While the repair is still visible the details of repair should be recorded.

6.7.4.9 Record of pipe

Record the following items:

i. any visible damage to the pipe;
ii. state of protective system or coating;
iii. depth of cover
iv. description of the soil/backfill.

6.7.5 Testing of Dry Repairs:

6.7.5.1 Give additional support to repaired pipe portion, if necessary;

All wet slurry should be removed to the extent possible, and the bottom of the excavation should be filled and the exposed pipe work rebedded, with suitable material sufficiently compacted to give adequate support to the invert and lower quadrants of the pipe and any fittings.

6.7.5.2 Renew bedding and compact

Additional material may be placed to support the repaired pipeline when under test pressure, but it is advisable to leave all joints visible in case of leakage.

6.7.5.3 Arrange air bleeding and slowly refill isolated section

Refilling the isolated section of the main with water should be done slowly and from one direction only. Arrangements should be made for the expulsion of the air by means of any convenient air valves, hydrants, washouts or taps. The repaired pipe is subjected to a pressure equivalent to the normal working pressure. The repaired pipe should remain under such working pressure until it is adjudged to be satisfactory. Some minor re-tightening of the joints may be necessary due to slight expansive movement of the assembly on being subjected to increase in pressure.

6.7.5.4 Control – Report situation to 'Control'.

6.7.6 Restoration

6.7.6.1 Restore valves and the system in accordance with the original operational plan

The repaired section of main is reintroduced to the system by restoring all valves to them original status.

6.7.6.2 Checking restoration

The restoration of the supplies to the normal situation supplied at important points should be checked.

6.7.6.3 Removal of temporary supplies

All standby pipes, temporary supplies and emergency tankers should be removed.

6.7.6.4 Notification

Notification and acknowledgments should be made wherever necessary. During the execution of the repair work hygienic conditions must be made to prevail at various stages till the completion of work.

6.7.7 Hygiene

6.7.7.1 Site cleanliness

During the repair work the area should be kept as clean as possible. All debris and contaminants should be removed from the site and the contamination of the trench from plant, equipment or any other potentially hazardous materials must be avoided.

6.7.7.2 Storage of tools and equipment

All pipes, fittings, tools, equipment and vehicles to be used on site should be regularly maintained and cleaned. Equipment used for disinfection and sampling should be kept for this purpose and regularly maintained.

6.7.7.3 Prevention of contamination during repair work

Clean and spray with disinfectant, on all surfaces that come into contact with potable water including the broken main, repair fittings and replacement pipe. Ensure that the contaminants do not enter the main where it is cut for repair. After completing the repair, flush the main at the nearest hydrant to remove any dirt etc.

6.7.7.4 Disinfection procedure

For small repairs which do not require the main to be cut, the fracture should be cleaned and this along with the repair collar should be sprayed with disinfectant. For more major repairs requiring cut out, every care must be taken to prevent contamination.

6.7.8 Completion

6.7.8.1 Finishing touches

Wherever joints have been left exposed for testing purposes these should be restored to their original position. The bolts, bare metal surfaces etc. should be properly protected prior to side fill.

6.7.8.2 Side filling work should be suitably accomplished

The dug material should be returned to the trench and placed in layers. The first side fill layer should be placed and compacted under the lower quadrants of the pipe and up to the springing level of the pipe. Successive layers of up to 100 mm thickness may then be placed and compacted to a maximum height above the crown of 250 mm. Light vibrating machinery may be used but not directly above the pipe or the fittings.

6.7.8.3 Clear site

On completion of the work all materials and protective barriers should be removed from site and the working area left clean and tidy. All records should be completed and submitted.

6.7.8.4 Notice of Completion

Notice of completion or interim or permanent reinstatement must be given within a reasonable period. Location of works and other relevant details should also be given.

6.7.8.5 Repair Method for different types of pipes

Some of the methods of repair for different types of pipes are given in the following tables.

Table 35: Pipes of Cast Iron

Material	**Cast Iron**	
Burst	**Action**	**Repair**
Joint failure	Enclose joint Two couplers	Special joint clamp Two couplers and new section
Brittle failure	Remove section/ joint Enclose failure	Two couplers and new section Repair collar or clamp
Corrosion	Remove section/ joint Rehabilitation technique Enclose failure	Two couplers and new section slip lining etc. Repair collar or clamp

Table 36: Pipes of Ductile Iron

Material	Ductile Iron	
Burst	**Action**	**Repair**
Joint failure	Enclose joint Two couplers	Special joint clamp Two couplers and new section
Extensive pin holing	Rehabilitation technique Remove section/ joint	Slip lining etc. Two couplers and new section
Ductile failure	Remove section/ joint Enclose burst	Two couplers and new section Repair collar or clamp
Localised pin holing	Enclose burst	Patch and weld Repair collar or clamp

Table 37: Pipes of Steel

Material	Steel	
Burst	**Action**	**Repair**
Extensive pin holing	Rehabilitation technique Remove section/ joint	Slip lining etc. Two couplers and new section
Joint failure	Remove section/ joint Enclose joint	Two couplers and new section Special joint clamp
Localised pin holing	Enclose burst	Patch and weld Repair collar or clamp

Table 38: Pipes of Asbestos Cement

Material	Asbestos Cement	
Burst	**Action**	**Repair**
Surface Softening	Remove complete pipe length	New pipe section and fittings
Longitudinal Cracking	Remove complete pipe length	New pipe section and fittings
Joint failure	Remove complete pipe length Enclose joint	New pipe section and fittings Joint repair clamp
Circumferential failure	Enclose burst	Repair collar or clamp

Table 39: Pipes of Prestressed Concrete

Material	Prestressed Concrete	
Burst	**Action**	**Repair**
Surface Softening	Remove complete length/ joint or cracking	Two couplers and new pipe section
Joint failure	Remove complete length/ joint Enclosed joint	Two couplers and new pipe section Special joint clamp

Table 40: Pipes of P.V.C

Material	Polyethylene/P.V.C	
Burst	**Action**	**Repair**
Fast crack propagation	Remove damaged section	Two couplers and new pipe section
Brittle failure	Remove damaged section Enclose burst	Two couplers and new pipe section Repair collar and clamp
Joint Failure	Cut out joint	Two couplers and new pipe section

Table 41: Pipes of Glass Reinforced Plastic Pipe

Material	Glass Reinforced Plastic Pipes (GRP)	
Burst	**Action**	**Repair**
Joint Failure	Enclose joint Replace joint	Joint clamp Repair collar and clamp
Delamination	Remove section Enclose failure	Two couplers and new section Repair collar and clamp
Fracture/ damage	Remove section Enclose failure	Two couplers and new section Repair collar and clamp

6.7.9 Repair Problems Specific to Pre-Stressed Concrete Pipes

The most difficult and time consuming repair problems relate to PSC Pipes, particularly the bigger diameter pipes. Some of the cases connected with the damage and leakage of such pipes along with their suggested methods are discussed below:

6.7.9.1 Extensive Damage to a PSC pipe Length

Sometimes the damage is so extensive that the entire length of a pipe needs replacement. The replacement is done by inserting a steel pipe which shall be fabricated in three pieces. One piece shall consist of a spigotted machine end, another of steel shell and the third a spigotted machine end. The middle portion shall be of steel barrel with an integral manhole. This man hole may be meant for temporary use only so as to be covered and rewelded suitably after the repairing operation has been satisfactorily carried out. The thickness of steel plate used for this purpose shall be equal to the design thickness plus 2 mm extra to take care of corrosion. A minimum of 10 mm may, however, be used. The burst pipe may be broken by taking due precautions and replaced with this set of three pieces. The two machine ends shall be fixed as per normal procedure for laying PSC pipes. The steel barrel shall be introduced in between and duly welded internally and externally.

6.7.9.2 Damage Restricted to a small length only

Sometimes the damage is along a length of 1 m to 1.5 m only and the remaining portion of the pipe remains in a sound condition. To make the damaged portion functional, two plain M.S. Barrels shall be inserted into the pipe, to suit the internal diameter with a gap of 25 mm. on either side of the pipe, 50 mm less than the internal diameter of the pipe, to facilitate jointing with jute and cement mortar. The barrels shall have 2 nos. 12 mm dia. M.S. rings to fix over the shell at the ends. At least 500 mm of overlap on either side of the pipe, length wise, is provided for jointing.
After following the normal procedure (as already discussed at length), break the damaged portion of the pipe to the extent (length wise) of cracks developed in the pipe for more than half of the pipe (diameter wise).
Cut the H.T. wires core reinforcement.
Clean the pipe internally, remove the broken debris and dewater the pipe. Insert one piece of the M.S. Barrel, duly fabricated with a temporary manhole for entry into the pipe for internal caulking, welding etc.
Shift barrel to one side so as to facilitate the insertion of the second barrel. Join the two pieces and weld the joint internally and externally.
Keep the barrel in position by covering the damaged portion duly keeping at least 500 mm of overlap for jointing with P.S.C. pipe. Insert the M.S. ring at the ends and place at 150 mm from the outer ends of the barrels and tag weld the rings to the barrel to caulk the jute firmly.
Caulk both the ends of the barrel with spun yarn for 3 layers and with cement mortar 1:1 duly mixing quick setting cement solution. Clean the pipe internally and paint with epoxy paint.
Close the manhole made on the M.S. pipe by welding and strengthening the joint with additional plates.
Weld angles on the barrel and support the edges of the PSC pipe.
Caulk the joints with cement mortar and cover the MS barrel with cement mortar. Embed the damaged portion of the pipe in cement concrete to avoid movement of the M.S. barrel during surge.
(As alternatives to the above procedure, there are other methods in use, depending upon the local conditions and the diameters of the pipes).
Follow other prescribed procedure for completion.

6.7.9.3 Leakage Through Socket/ Spigot joint due to displacement of rubber

The joint has to be exposed. A medium leakage can be attended without taking the shut down by pushing the rubber gasket to the original position with the help of wooden caulking tools and also inserting lead pieces in the joint. Afterwards, caulking with cement mortar 1:1 will further strengthen the joint. The entire joint has to be caulked with cement mortar.

6.7.9.4 Leakage through damaged socket

Such leakage can be attended only by taking shut down and draining the pipe line. The joint shall be exposed by excavating the trench around the joint. The crack and joint shall be filled with lead wool, quick setting cement mortar and the stepped split collar fixed over the joint and filled with cement slurry or cement mortar mixed with quick setting solution.

6.7.9.5 Leakage Through Hole

The hole can be covered with a plate and bolted to a flat inserted through the hole. The hole shall be covered with a lead washer under the plate and annular gap to be filled with mseal compound or other suitable sealing material. If the hole is very close to the joint, a plane cover or a stepped split collar can be fixed and caulked with cement mortar after caulking the joint with lead pieces or lead wool.

6.7.9.6 Generation of data and life cycle analysis

Record of repair carried out with costs should be maintained systematically. This will help in assessing the useful life of different materials of pipelines. This data will be useful in carrying out Life Cycle Cost analysis of competing materials and take decision regarding replacements.

6.7.10 Pressure Management

As system operating pressures are increased or decreased, the volume of annual real losses will increase or decrease proportionally.

Pressure management for leakage control, in its widest sense, can be defined as "The practice of managing system pressures to the optimum levels of service ensuring sufficient and efficient supply to legitimate uses and consumers, while reducing unnecessary or excess pressures, eliminating transient s and fault y level controls all of which cause the distribution system to leak unnecessarily."

There are several important factors that relate to the monitoring of the effectiveness of a Pressure Managed Area (PMA):

- Flow data monitoring – Daily Input volume and Night line monitoring
- Inlet and Outlet Pressure monitoring – indicative of PRV effectiveness, servicing requirement and available night time pressure control
- Burst frequency – Measure of burst frequency before and after installation.
- Reducing the water pressure in a system can be achieved in a number of ways each of which has advantages and disadvantages.

  The following techniques are discussed:

- Fixed outlet pressure control
- Fixed outlet pressure control involves the use of a device, normally a pressure reducing valve (PRV) which is used to control the maximum pressure entering a zone.
- PRVs are instruments that are installed at strategic points in the network to reduce or maintain network pressure at a set level. The valve maintains the pre-set downstream pressure regardless of the upstream pressure or flow-rate fluctuations. PRVs are usually sited within a DMA, next to the flow meter. The PRV should be downstream of the meter so that turbulence from the valve does not affect the meter's accuracy. It is good practice to install the PRV on a bypass pipe to enable future major maintenance works.
- Time-modulated pressure control

- The time-modulated pressure management option is effectively the same as the fixed-outlet system with an additional device which can provide a further reduction in pressure during off-peak periods. This form of pressure control is useful in areas where water pressures build up during the off-peak periods – typically during the night when most of the consumers are asleep.
- Flow modulated pressure control
- Flow modulated pressure control provides even greater control and flexibility than the time-modulated option. It will normally provide greater savings than either of the two previously mentioned options but this greater flexibility (and savings) comes at a price. The electronic controller is more expensive, and it requires a properly sized meter in addition to the PRV. It may not always be cost effective to use the flow modulated option and careful consideration should be given to the specific application before selecting flow-modulated control.

  It should be noted that there are numerous other forms of pressure control techniques which can be considered when trying to reduce losses from a water distribution system.

6.7.11 Periodical Reports

As the part of the all above activities the important part is presentation of reports. These periodic reports will submit by the each concerned execution team of above said activities in staged manner to LMC. This is also a type of data base generation and the reports includes day to day activities/observations and curdles, challenges faced etc. that from the scrap (at present) condition to targeted stages. These reports will be used by the management to regularly check and take actions as required. Also based on the history content of this periodic reports can be used for future reference also. Hence it is advised LMC to consider the documentation and presentation cost for generation of project outcome reports periodically. The types of periodic reports as mentioned below.

a) Design Report - detailing the design parameters used, network model constructed, and physical works proposed including cost estimate, etc.
b) PZT Completion Report - detailing the operations undertaken to complete the PZT and the results recorded.
c) NRW, Leakage Reduction & Control Progress Report - monthly report describing the NRW and leakage measurement, detection and repair activities undertaken, including a summary for the full project area.
d) Water balance report including NRW level and consumption analysis report.
e) DMA Files - Strategy Study, and Levels 1, 2 and 3 Reports. As the DMA files will be progressively developed.
f) Cost Benefit Analyses Reports- interim and final analyses as detailed above.
g) Final Project Report describing all activities undertaken and results achieved.

6.7.12 PMC Charges:

To manage such kind of unique activities of NRW reduction project requires an expertise with organizations and a thorough body of knowledge. Project Management Consultancy (PMC) plays multifaceted part in such projects and provides the services from inception to completion of projects. At every stage of project life cycle, the principles of pro-activeness and creating the win-win situation is necessary keeping in mind the client's requirements. Use of Project Management Consultancy (PMC) offers one of the effective management solutions to increase and improve the efficiency and outcome of an above said project. Project Management Consultants manage the Project by application of their Knowledge, Skills, and Experience at various stages. However, at the same time PMC also has to face various challenges like Design Issues, Constructability Issues, Long lead material Issues, Inter Contractor Coordination Issues, Engineering Issues, Safety Issues, etc which can be tackled only by a well-organized approach of the PMC.

6.7.13 Operations and Maintenance of NRW level

Level of NRW is higher in distribution network than source /transmission line. Hence O&M of NRW along source and transmission line can be easily controlled by regular monitoring of flow and pressure also leak detection whenever required. And transmission line the losses can be avoiding by preventive leakage management such as installation of PRV's, surge vessels etc. Hence it is mandatory to carry out regular monitoring of NRW level along distribution network. The sequence of O&M activities involves in distribution network described in this section.

The operation and maintenance of NRW will be start after the successful completion of design and construction activities related to NRW reduction. The operation and maintenance involve the following activities as furnished below. During the O & M period the team maintains the achieved targeted NRW level at the end of the design and construction period or further reduces to the extent possible.

a) Monitor performance of each DMA and source (flows, pressures, supply hours, leakage and NRW levels, etc.), and identify when remedial action needs to be taken.
b) Undertake leakage surveys as necessary for each DMA.
c) Locate and repair leaks and re-measure leakage and NRW until levels reduced to required values for each DMA.
d) To deal with Customer Complaints on meter problems. To undertake testing and replacement if necessary.
e) Maintenance of field instruments such as flow meters, telemetry pressure loggers, transmitters, PRV's etc. and all communication equipment.
f) Up-date the DMA Files as necessary. And preparation of monthly report such as water balance, NRW levels, progress, action taken to reduce the NRW, proposals for NRW reduction etc.

6.7.14 DMA Analysis & Routine Maintenance

6.7.14.1 Water in to Supply (WIS)

It is mandatory to monitor the regular water in to supply to each DMA to analyse the increase in water supply (flow rate) due to sudden leakages or un authorised connection and boundary valve operation. Hence the NRW team leader can understand the performance of each DMA. Also, it is mandatory to monitor the pressure such as inlet pressure, AZP, CPP etc.

6.7.14.2 Step Test

Step testing is an effective, flow based method of localizing flow loss within the DMA. To perform a step-test the inflow in to the zone must be monitored through the installed flow meters and valve operation activities to cut of the zones i.e. steps within the DMA. This demonstrates how much water in consumed in each step. Each step has an estimated consumer consumption which is compared to the drop-in flow at the inlet meter. If the difference between actual drop and consumption is significant, this provides an indication of leakage within that step.

Generally, step should be carried out when the demand is at the lowest i.e. at night time between 1.00 am to 4.00 am.

There are three types of valves when operating a step test –

a) Valves permanently shut to create DMA/ Zone called Boundary Valves
b) Valve needs to shut to create a step are called step valves
c) Valve that needs to be operated to isolate step from zone / inlet

It is important to allow setting time (minimum 15 minutes) between each step closure to have a stable and realistic flow rate. All the network events should be recorded to analyse as required.

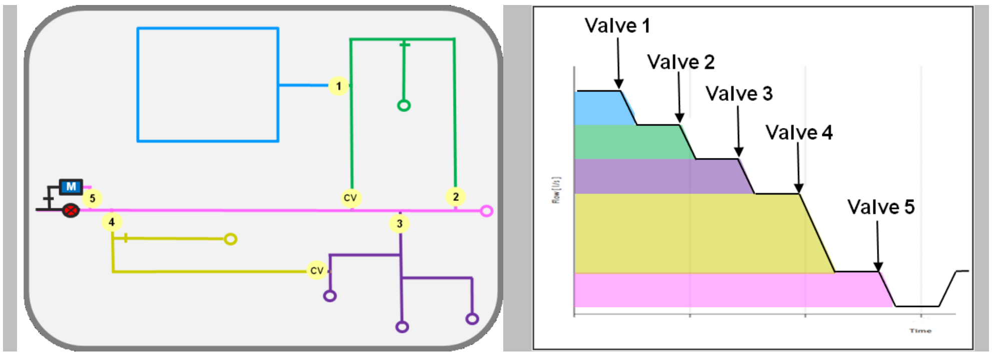


Figure 80: Typical Step Formation and Drop in Flow Rate per Step

6.7.14.3 Minimum Night Flow (MNF):

There are two methods to calculate component of real loss in overall NRW levels for each DMA.

Top down method:

The volume remaining after volume of authorized consumption and apparent loss have been deducted from the system input volume is the real loss component. When Real loses/ Leakage level are unknown for intermittent supply.

Bottom up method:

This method is applicable for DMA's having continuous pressurized supply. The real loss component is observed using Minimum Night Flow (MNF) usually between 1 am to 4 am. Real loses/ Leakage level are fixed through MNF gives realistic values by deducting legitimate night consumption.

6.7.15 Schedule of Maintenance

Asset maintenance schedule for various equipment's are summarized below.

S.N.	Asset	Activity	Frequency	Remark
1	DM	Observed flow and pressure through web GIS. Check for data loss & quality	Daily	
2	DM	Battery check-up	Monthly	
3	AZP/CPP	Observed pressure through web GIS. Check for data loss & quality	Daily	
4	Operating Valves	Valve should be operated as per SOP using suitable valve key	Daily	
5	Boundary Valve	Should be in closed condition unless otherwise needs to be open in emergency conditions	Monthly or sudden variation in inflow	

Source: Lucknow Municipal Corporation

Data needs to be checked every supply cycle and any anomalies should be reported in DMA packs. If data is not received in Web GIS for 3 consecutive cycles, data need to be downloaded from site and convey GIS/SCADA team to carry out trouble shooting if required.

6.7.16 NRW Performance Trigger & Trouble Shooting

Once the DMA is brought to the agreed NRW level, this needs to be maintained during the entire O&M period. Each DMA's NRW will be managed using intervention policy. The level of intervention is generally described below –

S.N.	Intervention Criteria	Activity	Detailed Action
1	Up to 5% increase in target NRW level	Regular Maintenance	Swipe DMA for Visible leaks Validate leakage prone areas based on past records Check on inlet pressure and supply hours / schedule Observe consumption data
2	From 5% to 10% increase in target NRW level	Active Sweeping	Swipe DMA for visible and invisible leaks in each and every supply Validate leakage prone areas by opening manhole covers / drain slabs Observed inflow and inlet pressure along with AZP/CPP for sudden variation Check boundary valve integrity Observe consumption data and carryout check readings

			Validate with O&M for any changes done in DMA or any new bulk consumers added etc. Carryout step test in leakage probe area Observe for consumer complaints for reduced supply or contamination to understand problem areas Use acoustic based equipment to pin point the leaks at the earliest and arrest immediately
3	More than 10% increase in target NRW level	Full active Leakage	Same as above plus check for burst near probable end caps , tee joints or culprit areas based on leakage history Pressure management in case inlet pressure has increased identify frequently leaking pipes section and proposed for replacement.

Source: Lucknow Municipal Corporation

6.7.17 Contingency Plans

Occasionally an event happens to disrupt normal operations. For these situations, contingency plans should be in place to provide clear guidance to team to effectively address operations. detailed contingency plan to be prepared & operated by O&M in case of emergency. Emergency situations may happen due to few of the following conditions.

Water Distribution	**Low / High System Pressure** **Water Main Breaks** **Valves Operations** **Poor Water Quality Incidents**

The physical works during O &M period can be summarized as follows:

a) Leak detection and repair of leaks in the water supply system
b) Consumer meter testing and replacement of damaged meters and installation of new meters for new customers.
c) Water quality monitoring and testing
d) Maintenance of Instrumentation system and Communication equipment such as SCADA centre, water billing system, all flow meters, loggers, sensors/transmitters etc. inclusive of associated accessories.

6.7.18 Leakage Detection & Rectification

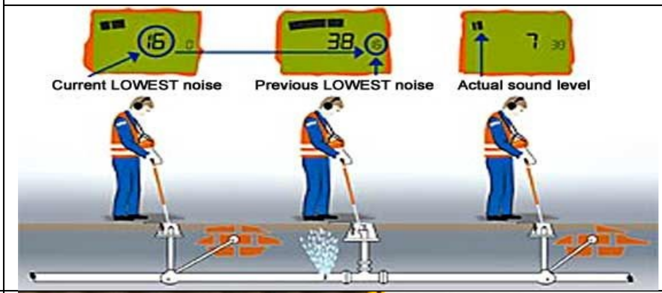
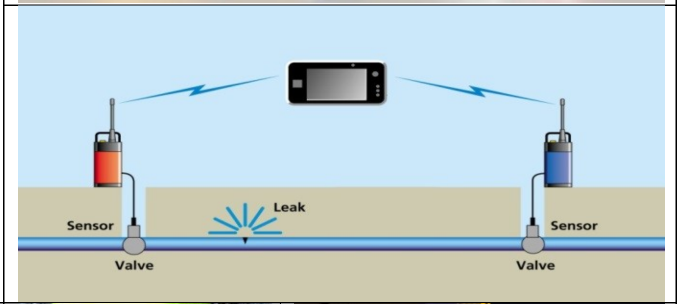
Leak detection work to be carried out in each DMA by observing night line flows between 2am to 4am i.e. during Minimum Night Flow (MNF) condition. If the flow during MNF exceeds the accepted flow limits, it will be notified by NRW engineer and he will arrange a team to carryout step test to identify leak pocket / pipe stretch. Once the leaky pocket / pipe stretch is identified, leak detection engineers will pin point the leak using acoustic based equipment's i.e. Listening Stick, Ground Microphone, Leak Noise Correlators etc. After pin pointing, leak will be rectified by leak repair team by closing supply in that particular stretch. Once the leak is rectified, flow during MNF will be observed again. Leak detection & rectification activity will continue till MNF reduces to acceptable flow rate. Restoration of leak pit will be done by road restoration team immediately after confirmation from leak rectification team.

6.7.19 Deployment of Manpower & Equipment's during leak detection activities

For continuous leak detection and monitoring, we have deployed team of trained Engineers. A team of 2 to 4 engineers will be deployed to one pocket with necessary equipment's for leak detection. During night time, team will visit the part of DMA where leaks are suspected (based on result of step test) and they will observe for visible leaks and will also try to pin point for invisible leaks if any.

Table 42: Equipment used for Leak Detection

Pipe Locater- Pipe locater will be used to identify underground pipeline alignment.	
Listening Stick – Used for listening on pipe fittings, valves, or water meters Sound is conducted up a metallic probe Two types of listening stick; Mechanical and Electronic.	 
Electronic Listening Stick – Leak Noise is amplified by the electronics Headphones are used to listen to leak noise helps muffle ambient noise	
Ground Microphone – Used to listen for noise emanating from leaks that are underground On surfaces such as tarmac, pavement, grass fields, etc. Sophisticated sensors that is shielded from the background noise like the wind Minimum Noise Level – the constant background noise (related to leakage), not including traffic or other 'people' related noise Instantaneous (non-minimum) sound level	

	
Leak Noise Correlators – Two sensors (red and blue) are positioned either side of the suspected leak position. The time taken for the leak sound to reach respective sensors is measured. Knowing the velocity of sound and distance between sensors, a leak position is determined from the difference of each transmitter's time to the leak.	 
Multi-correlating Noise loggers – Coverage of an area in one 'hit' Loggers may be deployed during the day and retrieved the next day (minimising night-work) Many "points of interest" can be found and reported for investigation Night-time operation is the optimum time for leak sound Three sound 'epochs' per night to separate genuine water use from leakage	 
Portable Ultrasonic Flowmeter Battery-operated Instant values (flowrates, totals) shown on LCD display Internal data logger Transducers installed on outside of pipe - no interruption to flow Can be used on a variety of pipe sizes	

Pressure Data Loggers - Data Loggers are devices that record pressure from designated points in Network. Small, robust and submersible (IP68) Event and/or interval logging (1second to 24hours Analogue accuracy to ±0.1% Large memory (2Gbyte) Secure long and rapid deployments USB rapid local communications Batch programming external power options Results can then be viewed or graphed with the host software		
Tracer Gas Detector – This method of leak detection is used where pressure in the pipe line network is not suitable for acoustic based LD equipment's. In this method Foam Gas (95% Nitrogen and 5% Hydrogen) will be injected in isolated pipe section (preferably all HSC and branches in closed condition) with designated pressure. Gas will come out from the existing cracks, holes in the pipelines. This escaped gas will be traced by traces / sniffer by walking along the pipe line alignment. Leak will be indicated by louder noise made by tracer unit and thus location of pinpointed leak will be marked for excavation.		

Material used for Leak Rectification –

Typically, following material is being used for leak rectification works in project area.

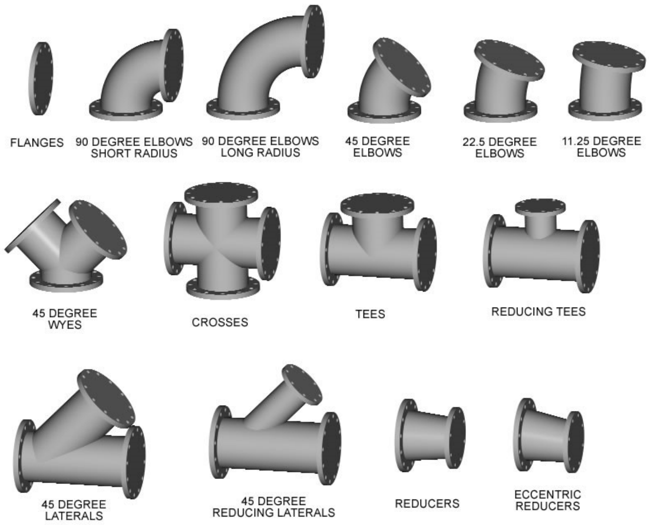


Figure 81: Materials for Leak Rectification Works

6.7.20 Consumer Meter Testing

It is mandatory to undertake testing of the meter and/or replace malfunction/damaged meters to reduce apparent losses such as meter in accuracy and meter tampering etc. This will increase the revenue as well. Identification of illegal connections and regularization is the continuous activities, the same can be analysed vide data analytic of consumption data and smart billing system. Meter test bench to be established to calibrate the consumer meter as per the manufacture recommendation. Consumer maters to be calibrated periodically with a meter test bench accredited by NABL.

Figure 82: Consumer meter test bench

6.7.21 Water Quality Monitoring and Testing

Water samples shall be taken after each pipe repair and reservoirs to ensure the quality of water and check the chances of contamination, chlorine content etc. Water quality tests shall be conducted for physical, chemical and biological parameters as per the standards. The test results should be within the permissible limits as per ISO standard. The water quality management to be prepared and need to be followed.

6.7.22 Maintenance of Instrumentation System, DMA meters inclusive of associated accessories.

Periodic device inspection, calibration, preventive maintenance, repair/replace, testing of all installed equipment inclusive of accessories to be carried out. Maintenance service for the instrumentation system and Wireless communication system together with testing and/or calibration of DMA meters, Flow & pressure transmitters, Electronic Systems, Software to be carried out. Inspection of Wire, Cable and Connections to be carried out. Replacement and/or repair of batteries, faulty sets and all other non-functional equipment to ensure trouble free communication.

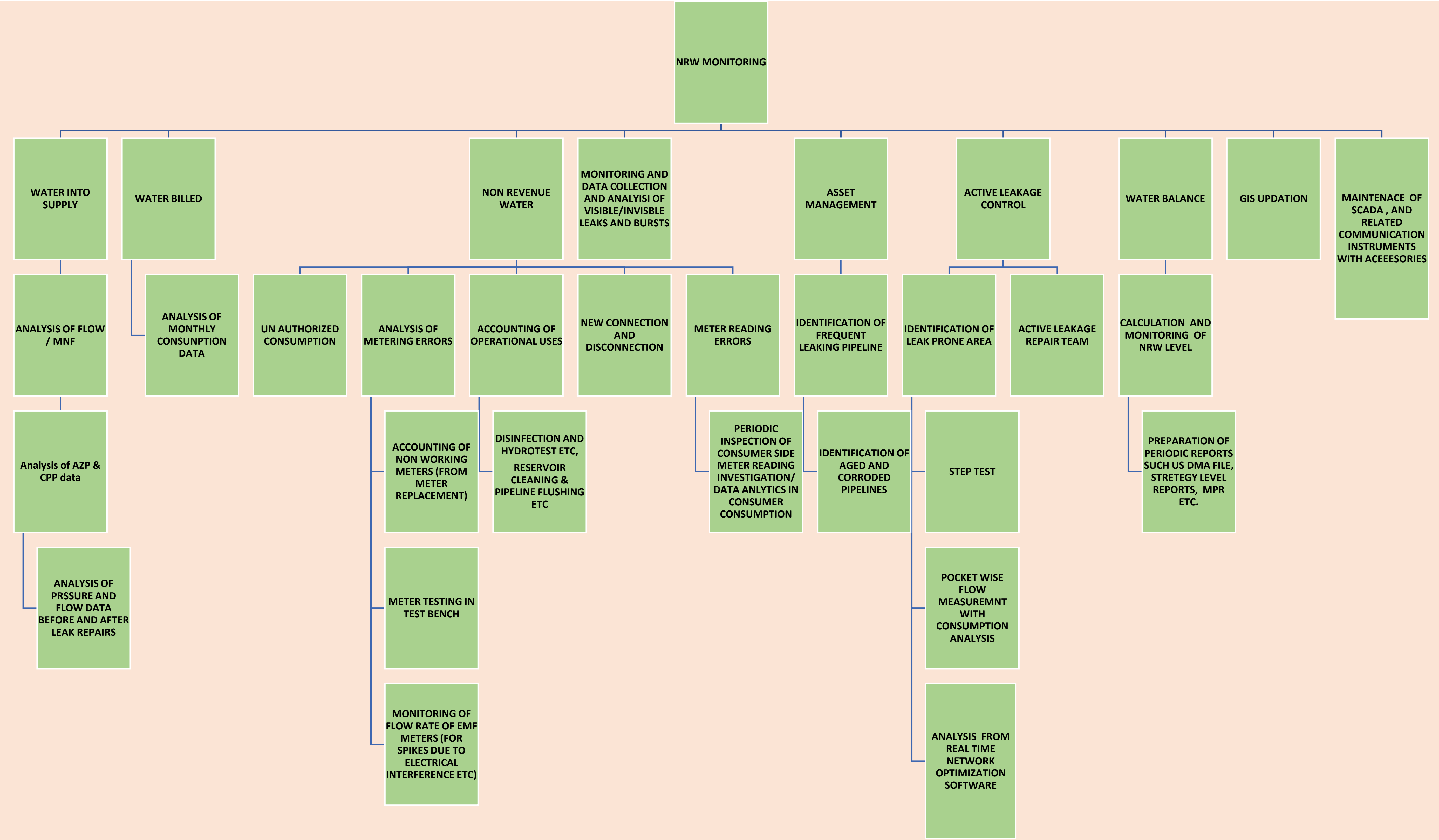


Figure 83: Operation and Maintenance Activities Flow chart

7 PERFORMANCE INDICATORS

Monitoring Performance of NRW Management

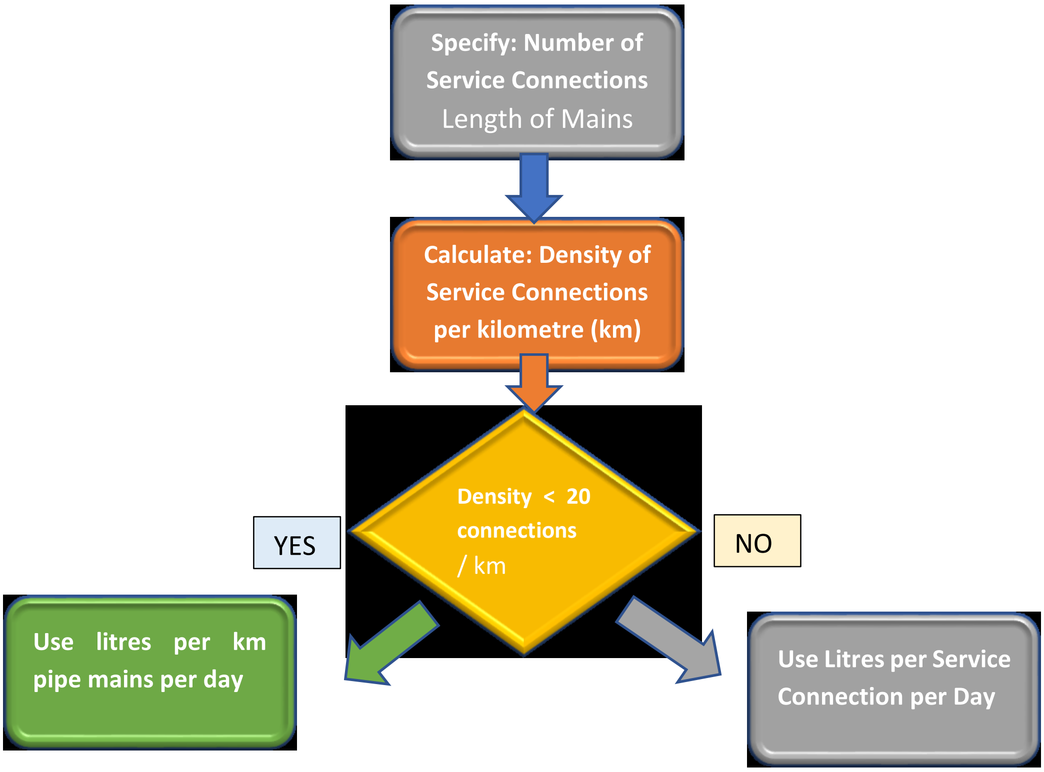
NRW is a measure of a utility's efficiency in terms of both operational performance and financial Performance. Managers, policymakers, regulatory agencies, and financing institutions use NRW performance indicators (PIs) to rank the utility's performance against industry standards and other water utilities. This chapter reviews common performance indicators for physical and commercial losses and briefly describes monitoring programmes.

7.1 CHARACTERISTICS OF PERFORMANCE INDICATORS

- Performance indicators help a utility:
- Better understand water losses
- Define and set targets for improvement
- Measure and compare performance
- Develop standards
- Monitor compliance
- Prioritise investments

A good NRW PI should be clear and easy to understand and have a rational basis. It should also be easy to calculate using data that the utility gathers regularly. Finally, utilities should include standard performance indicators to measure performance to facilitate comparisons with other utilities. Tools such as decision trees are available for managers to select appropriate performance indicators for their utility's needs and operating context.

The below figure helps to choose PIs for the network. For example, in an urban network, where the housing density is usually greater than 20 connections per kilometre of mains, the most appropriate PI would be litres/ service connection/day and if the density of connections is less than 20 the m3 per km of mains per day should be used. To take account of networks with varying pressures, the utility can enhance the PI by expressing losses in litres per connection per day per metre of pressure (l/connection/day/m).



Source[21]:

Performance indicators for physical losses

7.2 EXPRESSING NRW AS A PERCENTAGE

NRW has traditionally been expressed as a percentage of input volume. Although this is preferable to setting no targets at all, it is misleading as a PI because it favours utilities with high consumption, low pressure, and intermittent supply. In addition, it does not differentiate between physical losses and commercial losses. Nevertheless, NRW as a percentage of input is some-times useful for its 'shock value'—a high result can be a spur a utility to initiate a study of the network's operational performance and to conduct a water balance calculation. It is also useful as a measure of the utility's year-on-year financial performance, as long as the measurement principles are consistent. In that case, it should be expressed as the value, not the volume, of water lost.

Appropriate indicators of physical losses include:

- Litres per service connection per day (l/c/d)
- Litres per service connection per day per metre of pressure (l/c/d/m pressure)
- Litres per kilometre of pipeline per day (l/km/d)

[21] Malcolm Farley and Stuart Trow, Losses in Water Distribution Networks, IWA Publishing, 2003.

7.3 RECOMMENDED PERFORMANCE INDICATORS FOR PHYSICAL LOSS AND NRW

Table shows the Infrastructure Leakage Index (ILI) and other recommended NRW and physical loss performance indicators based on the IWA's *Performance Indicators for Water Supply Services: IWA Manual of Best Practice*.

L/c/d gives a more accurate picture than NRW as a percentage of input volume, but taking system pressure into account (l/c/d/m pressure) is an even better indicator. The PIs are categorized by function and level, defined as follows:

- Level 1 (basic): A first layer of indicators that provides a general management overview of the efficiency and effectiveness of the water undertaking.
- Level 2 (intermediate): Additional indicators that provide a better insight than the Level 1 indicators; for users who need to go further in depth.
- Level 3 (detailed): Indicators that provide the greatest amount of specific detail, but are still relevant at the top management level.

Function	Level	Performance Indicator	Comments
Financial: NRW by Volume	1 (Basic)	Volume of NRW [% of System Input Volume]	Can be calculated from simple water balance not too meaningful
Operational: Physical Losses	1 (Basic)	[Litres/service connection/day [Litres/km of mains/day] (only if service connection density is < 20/km)	Best of the simple 'traditional' performance indicators, useful for target setting, limited use for comparisons between systems
Operational: Physical Losses	2 (Intermed.)	[Litres/service connection/day/m pressure] [Litres/km of mains/day/m pressure] [only if service connection density is < 20/km)	Easy to calculate indicator if the ILI is not known yet, useful for comparisons between systems
Financial: NRW by cost	3 (Detailed)	Value of NRW [% of annual cost of running system]	Allows different unit costs for NRW component, good financial indicator
Operational: Physical Losses	3 (Detailed)	Infrastructure Leakage Index (ILI)	Ratio of current annual Physical losses to unavoidable annual real losses, most powerful indictor for comparisons between systems

Source [22]

[22] Alegre H., Hirner W., Baptista J.M. and Parena R. (2000) Performance Indicators for Water Supply Services: IWA Manual of Best Practice. ISBN 900222272.

7.4 THE INFRASTRUCTURE LEAKAGE INDEX (ILI)

The Infrastructure Leakage Index (ILI) is an excellent indica- tor of physical losses, one that takes into account how the net-work is managed. The IWA, which developed the index, and the American Water Works Association (AWWA) Water Loss Control Committee both recommend this indicator. The ILI is particularly useful in networks where NRW is relatively low, for example below 20%, as the ILI can help to identify which areas can be reduced further. The ILI is a measure of how well a distribution network is managed (i.e. maintained, repaired, and rehabilitated) for the control of physical losses, at the current operating pressure. It is the ratio of Current Annual Volume of Physical Losses (CAPL) to Minimum Achievable Annual Physical Losses (MAPL).

ILI = CAPL/MAAPL

Being a ratio, the ILI has no units and thus facilitates comparisons between utilities and countries that use different measurement units. The complex initial components of the MAAPL formula have been converted to a format using a pre- defined pressure for practical use:

MAAPL (litres/day) = (18 x Lm + 0.8 x Nc + 25 x Lp) x P

Where Lm = mains length (km); Nc = number of service connections; Lp = total length of private pipe, property boundary to customer meter (km); and P = average pressure (m).

Figure illustrates the ILI concept with the factors that influence leakage management. The large square represents the CAPL, which tends to increase as the distribution networks grow older. This increase, however, can be constrained by a successful leakage management policy. The black box represents the MAAPL, or the lowest technically achievable volume of physical losses at the current operating pressure. The ratio of the CAPL to MAAPL, or the ILI, is a measure of how well the utility implements the three infrastructure management functions—repairs, pipelines and asset management, and active leakage control. Although a well- managed system can have an ILI of 1.0 (CAPL = MAAPL), the utility may not necessarily aim for this target, since the ILI is a purely technical performance indicator and does not take economic considerations into account.

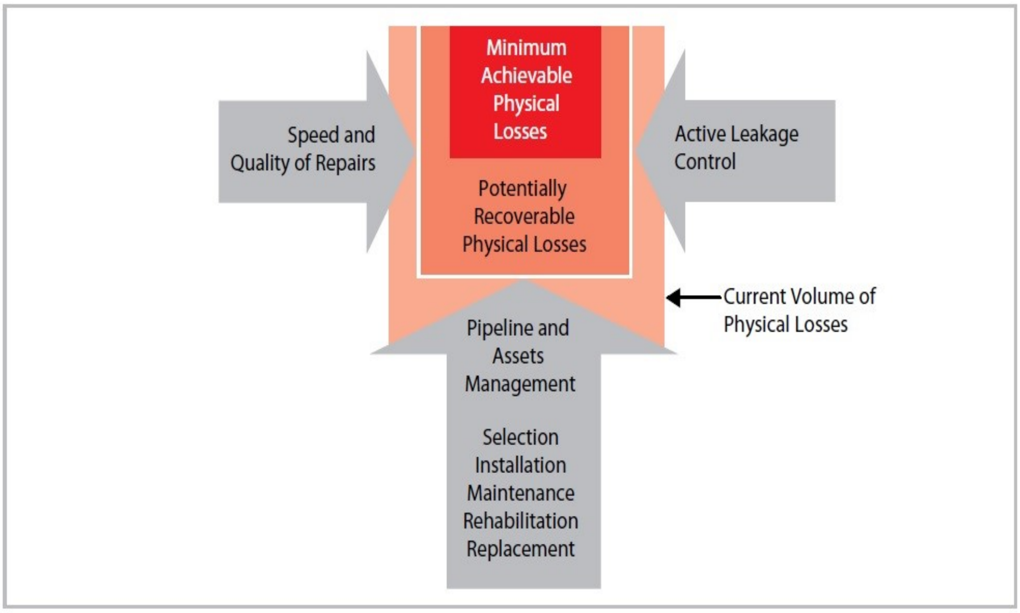


Figure 84: ILI concept

Calculating the ILI

- Step 1. Calculate the MAAPL
- Step 2. Calculate the CAPL (e.g. from the Water Balance)
- Step 3. Calculate the ILI (CAPL/MAAPL)
- Step 4. Adjust for intermittent supply (divide MAAPL by the average number of supply hours per day)
- Step 5. Compare ILI with physical loss target matrix

Table shows The physical loss target matrix shows the expected level of ILI and physical losses in l/c/day from utilities in countries at differing levels of network pressure. It should be noted that this is a very subjective assessment and the indicators are provided as a rough guide and should not be taken as strict limits. In many parts of Africa and Asia, very high ILI values are often experienced and the limits given in Table tend to become meaningless. The main purpose of the ILI indicator is to help identify areas where leakage/losses are abnormally high to ensure that action is taken in the most appropriate areas. Once the ILI value is above 10 or 20 for example, it is clear that the area being investigated requires attention. In some cases, values in excess of 100 are experienced and once again this simply highlights that there is a severe problem that should be addressed.

NRW Team can use the matrix to guide further network development and improvement: Category A — Good. Further loss reduction may be uneconomic and careful analysis needed to identify cost-effective improvements.

Category B — Potential for marked improvements. Consider pressure management, better active leakage control, and better maintenance.

Category C — Poor. Tolerable only if water is plentiful and cheap, and even then intensifies NRW reduction efforts.

Category D — Bad. The utility is using resources inefficiently and NRW reduction programmes are imperative.

7.5 PHYSICAL LOSS TARGET MATRIX

Technical Performance Category		ILI	Litres/connection/day (when the system is pressurised) at an average				
			10 m	20 m	30 m	40 m	50 m
Low and Middle Income Countries	A1	< 2	< 25	< 50	< 75	< 100	< 125
	A2	2-4	25-50	50-100	75-150	100-200	125-250
	B	4 - 8	50-100	100-200	150-300	200-400	250-500
	C	8 - 16	100-200	200-400	300-600	400-800	500-1000
	D	> 16	> 200	> 400	> 600	> 800	> 1000

Source [23]

Performance Indicators of Commercial Losses

The IWA Water Loss Task Force is also developing a performance indicator for commercial losses similar to the ILI.[6] The indicator uses a base value of 5% of water sales as a reference, and the actual commercial loss value is calculated against this benchmark. This is the Apparent (Commercial) Loss Index (ALI).

Apparent Loss Index (ALI) = Apparent loss value ÷ 5% of water sales

A commonly used indicator that expresses commercial losses as a percentage of water supplied is misleading because it does not reflect the true value of lost revenue. Currently, the best indicators to measure commercial losses as a percentage of authorised consumption.

[23] World Bank Institute

Table 43: Apparent Loss Performance Indicators

Apparent Loss Performance Indicators	Best Estimate	Error Margin [+/- %]	Lower Bound	Upper Bound
Apparent Losses expressed in % of Authorised Consumption	3%	20%	2%	3%
litres/connection/day	28	5%	26	29
liters/customer/day	24	5%	22	25

Volume of Real Losses	Best Estimate	Error Margin [+/- %]	Lower Bound	Upper Bound
CARL - Current Annual Volume of Real Losses [m3/day]	3,84,385	5%	3,65,609	4,03,160
UARL - Unavoidable Annual Real Losses [m3/day]	3,375	3%	3,268	3,481

Table 44: UARL & CARL

Table 45: Real Loss Performance Indicators

Real Loss Performance Indicators	Best Estimate	Error Margin [+/- %]	Lower Bound	Upper Bound
Infrastructure Leakage Index (ILI)	114	6%	107	121
Litres per Connection per Day (w.s.p.) w.s.p.: when the system is pressurised - this means the value is already corrected in the case of intermittent supply	981	6%	925	1,038
Litres per Connection per Day per meter Pressure (w.s.p.)	123	6%	115	131
m3/km mains per hour (w.s.p.)	4.16	6%	3.92	4.40

Performance Group	
Standard	Low and Middle Income Countries
D	D
Explanations	Explanations

Table 46: NRW Performance Indicators

NRW Performance Indicators	Best Estimate	Error Margin [+/- %]	Lower Bound	Upper Bound	Performance Group: Standard	Performance Group: Low and Middle Income Countries
Volume of Non-Revenue Water expressed in % of System Input Volume	55%	4%	52%	57%	D	D
Value of Non-Revenue Water expressed in % of Annual Operating Cost	64%	4%	61%	67%		
Litres per Connection per Day (w.s.p.) w.s.p.: when the system is pressurised - this means the value is already corrected in the case of intermittent supply	1,113	5%	1,055	1,172	Explanations	Explanations

Table 47: Revenue losses of LMC due to NRW

Financial Information		
	per m3	Currency
Average Tariff	2.50	INR
Variable Production and Distribution Cost (Marginal Cost of Water)	6.90	INR
NRW Component	Annual Value	
Unbilled Metered Consumption	-	INR
Unbilled Unmetered Consumption	3,73,28,550	INR
Apparent Losses	98,98,140	INR
Customer Meter Inaccuracies and Data Handling	-	INR
Unauthorised Consumption	98,98,140	INR
Real Losses	60,68,41,769	INR
Total Volume (m3/d): 3,84,385		
Volume which could be sold to existing or new customers (m3/d): 2,24,926		
Total Value of NRW	65,40,68,459	INR
Annual Operating Cost (without Depreciation)	1,03,06,38,000	INR

8 INSTITUTIONAL MANAGEMENT

8.1 IMPROVEMENT AREAS IN LUCKNOW

The water balance for Lucknow has shown 54.70% of water as non-revenue water.

Table 48: Key Improvement Areas for Lucknow

Intervention areas for NRW Reduction	Targeted Outcome	Recommended set of activities for realizing objectives and outcomes
Non-availability of updated and detailed information of the Water Supply System	Updated and accurate knowledge of the system for efficient NRW reduction & monitoring O&M.	• Setting up digital layout of the updated network and system components on GIS • On site verification and GIS digitalization of existing pipelines and other distribution works • Updated database of the connections' location and related user data
Inadequacy of the available human resources at LMC	Achieve efficient NRW monitoring and O&M of the system, billing and collection of water charges, improved relation with the consumers	• Training of existing staff and hiring new expert • Re-organization and strengthening of the Water Supply Department • Special training on NRW management and latest adopted practices globally • Outsourcing of specialized activities with knowledge transfer and training modules designed
Consumer Awareness	Educated and aware consumer with increased willingness to pay	• Various measures could be undertaken by LMC and Jal Kal to make consumers aware about cautious use of water • Detailed approach shared in Section 12.14
Total revenue losses of 51.745 MLD with 10.837 MLD as apparent loss 40.908 MLD as unbilled authorized consumption	**Reduction of revenue losses**	• **Installation of meters for all consumer connections (suggested Class B meter)** • **Setting of efficient reading method for water consumption volumes** • Regularize all illegal connections (3% of actual consumption illegal connection as informed by LMC) • **Correct classification of commercial connections** • **Billing of authorized consumers (5.13%)**
Drawbacks in water billing and collection	Achieve cost efficiency with consumption based billing	• Revision of tariff structure from ARV based to telescopic model • Implementation of Smart Water Management System (SWMS)
Total Real loss of 384.40 MLD (88.14% of total NRW)	Overall NRW to be reduced up-to 20%	• Implementing Leak Detection and Rectification activities • Active Leakage Management

		• Repair and maintenance of civil structures like ESRs, GSR, sumps, WTPs, etc. • Replacement of PVC, PSC, AC pipes to DI • Rehabilitation/replacement of old CI pipes • Installation of SCADA for systematic NRW management
Difficulty in establishing reliable water balance due to lack of flow meters	Systematic collection, collation and analysis of existing system	• Metering at production, transmission (EMF meter) and distribution level • Establishment of DMAs for continuous monitoring of inflow of water and consumed water • Measurement of inflow and outflow volumes in all trunks lines, reservoirs and WTPs • Installation of SCADA to keep systematic water audit
Unequal distribution of water in various parts of the City	**Uniform water supply services throughout the city**	• **Equitable distribution of water will become possible** • **Proper and regular O&M of service reservoirs and network mapping of all assets** • **DMA setup with hydraulic modeling and pressure management instruments installation for uniform water supply**

9 NRW MANAGEMENT ACTIVITIES

9.1 NRW STRATEGY

9.1.1 Holistic NRW Strategy

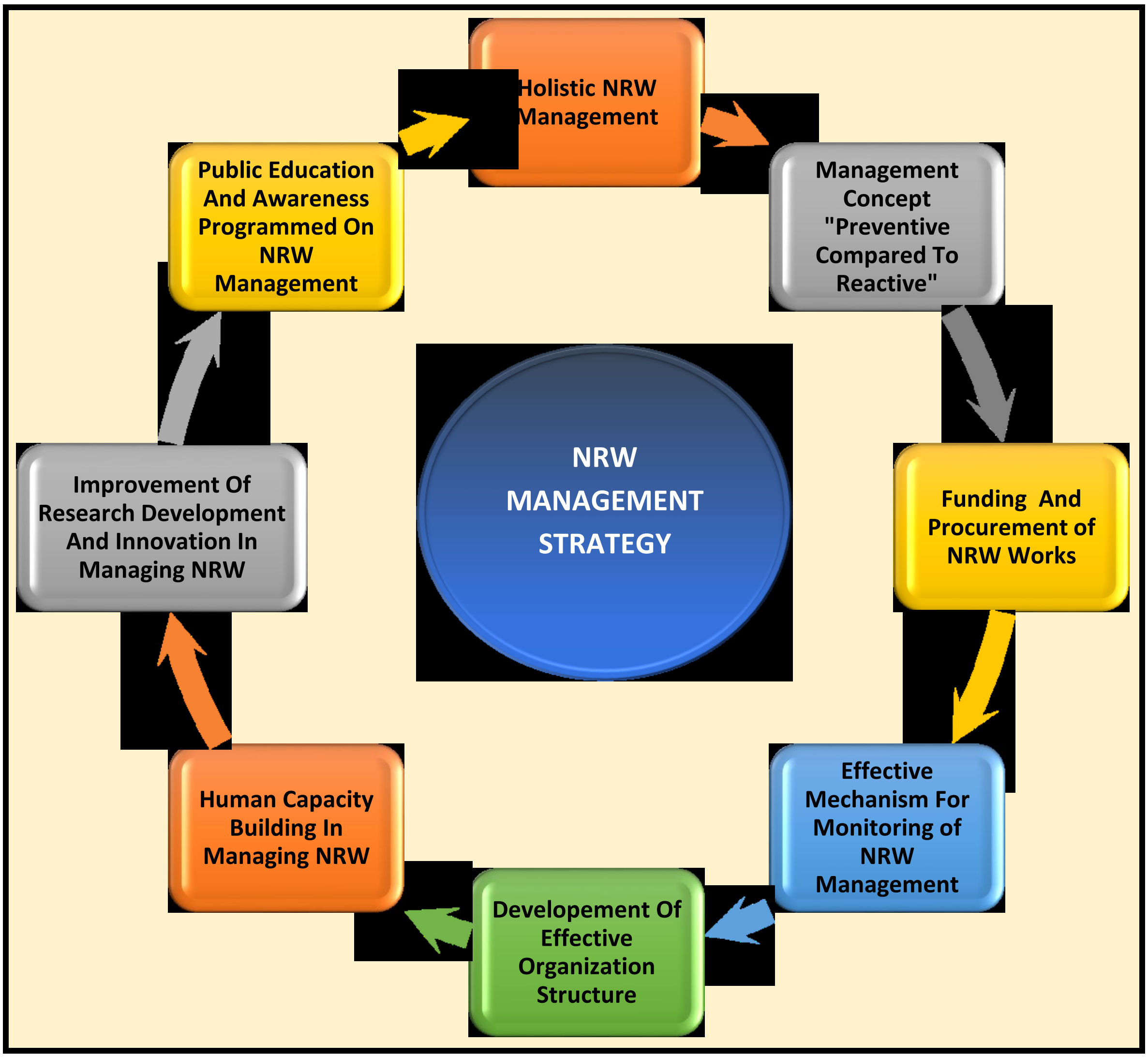


Figure 85: HOLISTIC NRW STRATEGY

This NRW management strategy it is a Holistic approach which is that, it is the concept "Preventive Compare to Reactive". It includes funding and Procurement of NRW works. Then there is effective mechanism for monitoring NRW Management. Developing of Effective Organization Structure. It then includes Human Capacity Building in Managing NRW. After that there is an Improvement of Research Development and Innovation in Managing NRW. Then there is Public Education and Awareness Programme on NRW Management.

9.1.2 Holistic NRW Management

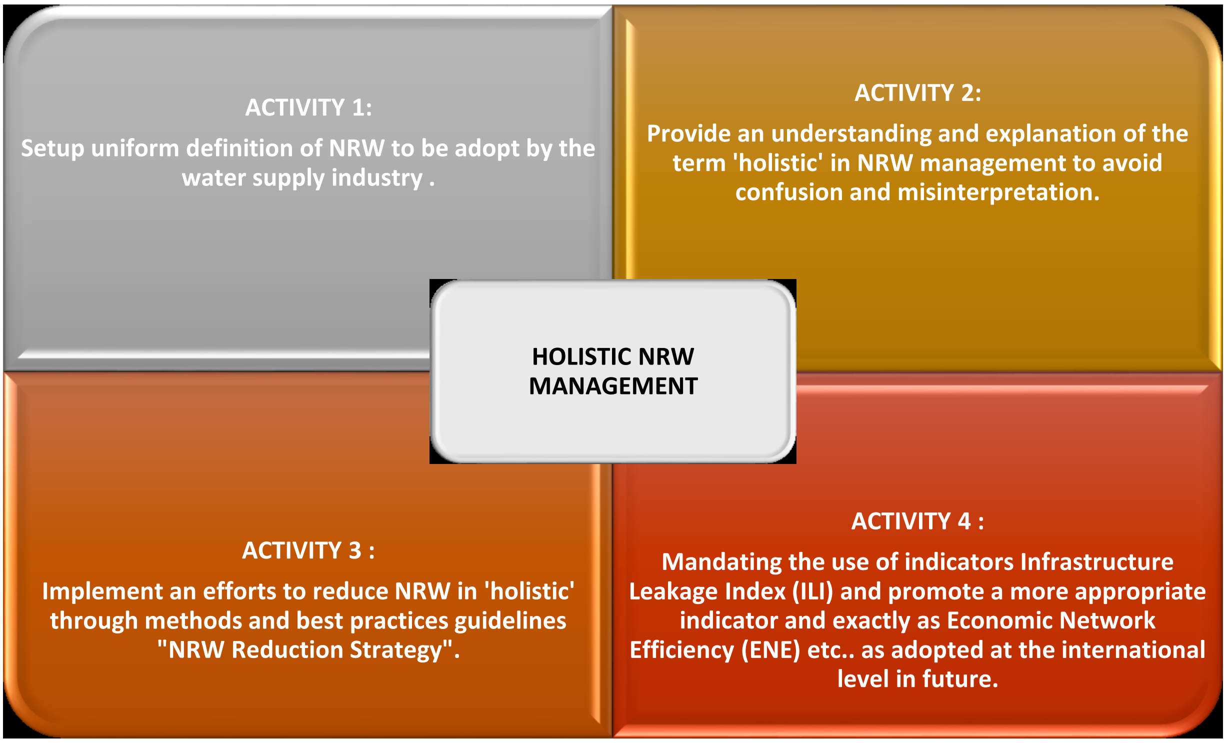


Figure 86: HOLISTIC NRW MANAGEMENT

This NRW management is a Holistic approach which is including four activities.

- First activity includes properly set up uniform definition of NRW to be adopted by the water supply industry.
- Second activity provides an understanding and explanation of the term 'holistic' in NRW management & also to avoid confusion and misinterpretation.
- Third activity is an implementation of an effort to reduce NRW in 'holistic' through methods and best practices guidelines "NRW Reduction Strategy".
- Fourth activity includes Mandating the use of indicators Infrastructure Leakage Index (ILI) and promote a more appropriate indicator and exactly as Economic Network Efficiency (ENE) etc. as adopted at the international level in future.

9.1.3 Holistic NRW Activities for Lucknow

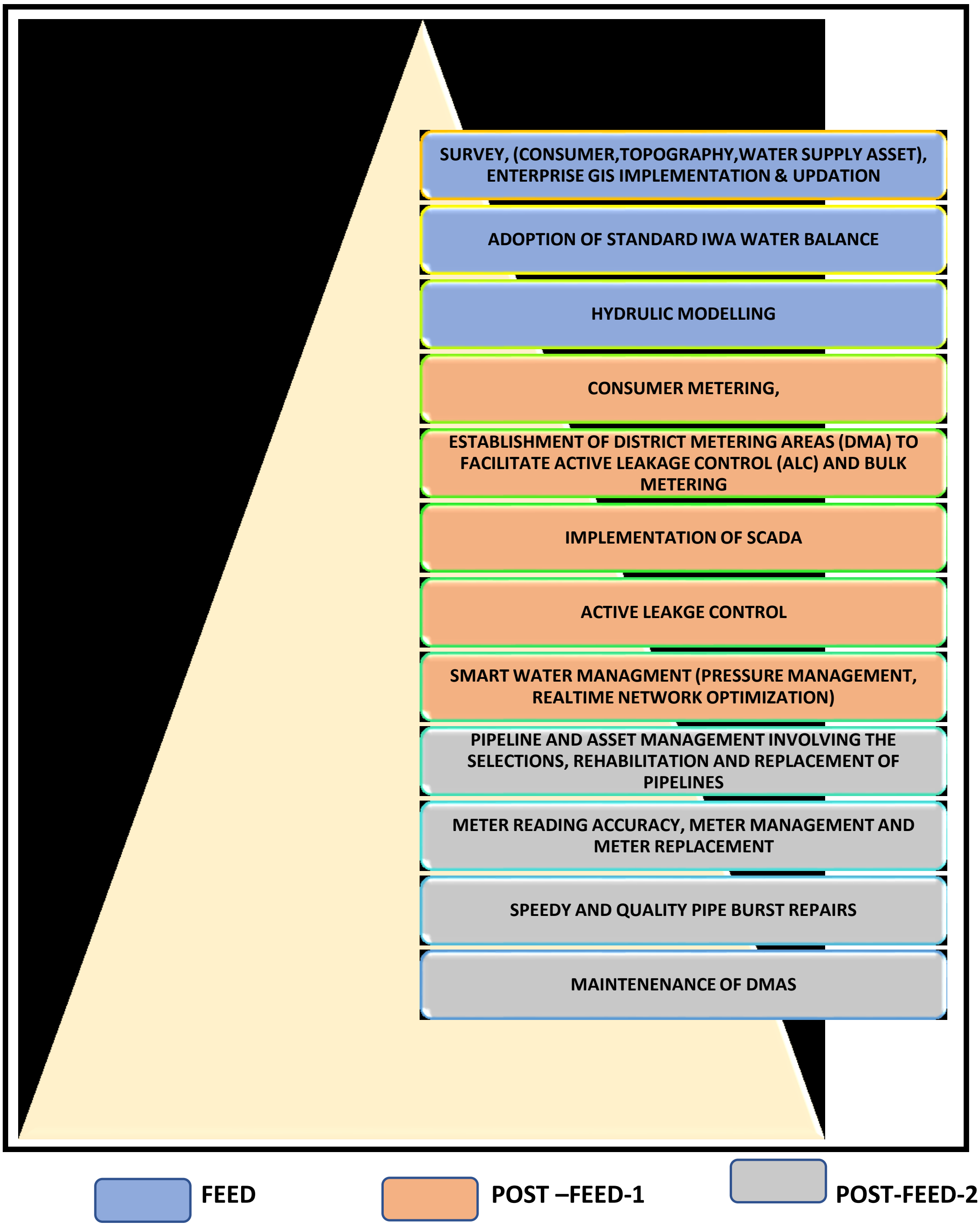


Figure 87: HOLISTIC NRW ACTIVITIES FOR LUCKNOW

Feed activity includes Survey, (Consumer,Topography,Water Supply Asset), Enterprise Gis Implementation & Updation, Adoption Of Standard Iwa Water Balance & Hydraullic Modelling.

Post Feed-1 includes Consumer Metering, Establishment Of District Metering Areas (Dma) To Facilitate Active Leakage Control (Alc) And Bulk Metering , Implementation Of Scada, Active Leakge Control, Smart Water Managment (Pressure Management, Realtime Network Optimization)

Post Feed-2 includes Pipeline and Asset Management involving the Selections, Rehabilitation and Replacement of Pipelines, Meter Reading Accuracy, Meter management and meter Replacement, Speedy and Quality Pipe Burst Repairs, Maintenenance of DMAs.

9.1.4 Management Concept

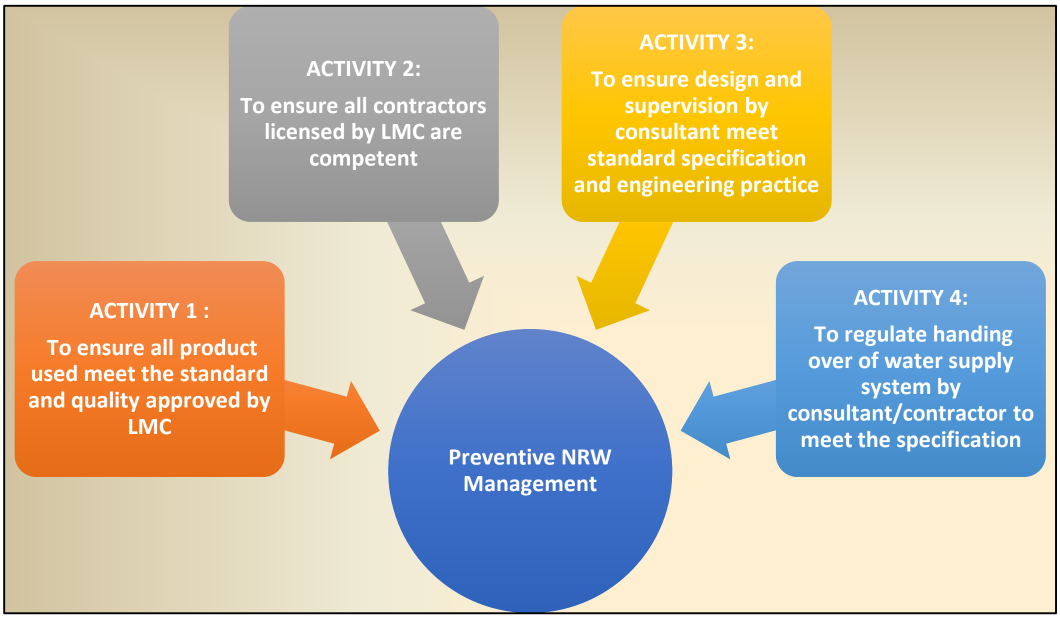


Figure 88: MANAGEMENT CONCEPT 'PREVENTIVE COMPARED TO REACTIVE'

Preventive NRW Management includes

- First activity is to ensure all product used meet the standard and quality approved by LMC.
- Second activity is it to ensure all contractors licensed by LMC are competent.
- Third activity is further it ensure design and supervision by consultant meet standard specification and engineering practice.
- Fourth activity is it then it regulates handing over of water supply system by consultant/contractor to meet the specification.

9.1.5 Funding FOR NRW Reduction Activities

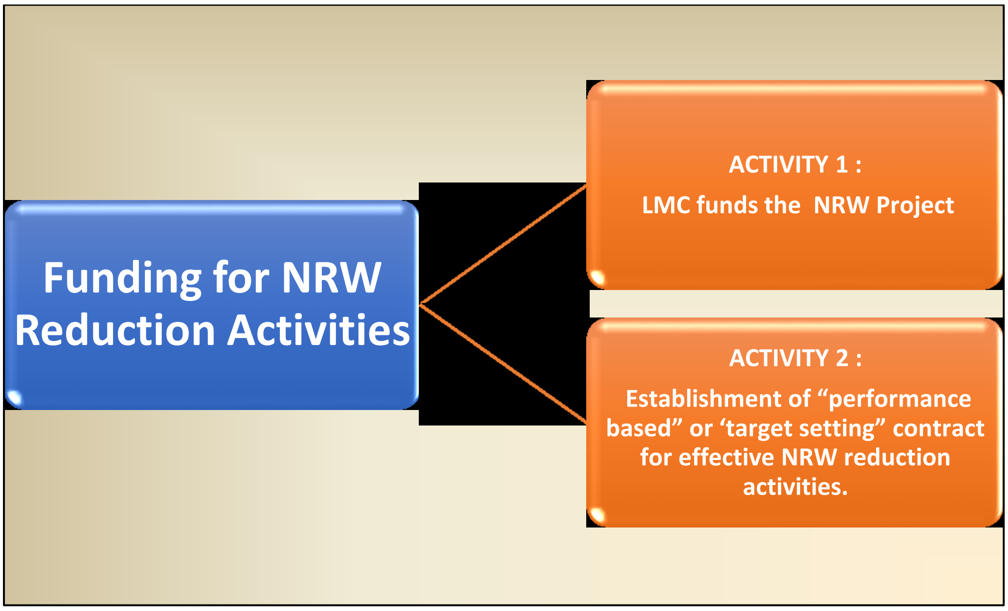


Figure 89: FUNDING AND PROCUREMENT OF NRW WORKS

Funding for NRW reduction activities

- First activity includes the LMC arranging the fund on NRW activity.
- Second activity is to Establishment of "performance based" or 'target setting" contract for effective NRW reduction activities.

9.1.6 Effective Mechanism for Monitoring of NRW Management

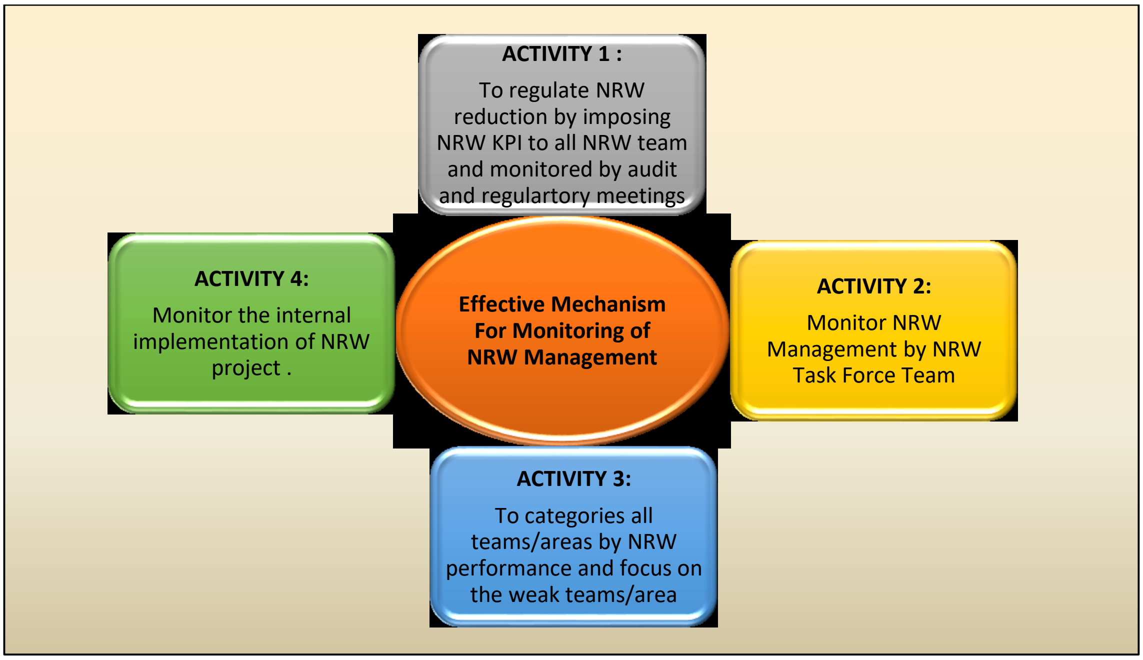


Figure 90: EFFECTIVE MECHANISM FOR MONITORING OF NRW MANAGEMENT

Effective Mechanism for Monitoring of NRW Management includes

- First activity is it regulates the NRW reduction by imposing NRW KPI to all NRW team and monitored by audit and regulatory meetings.
- Second activity is then it Monitor NRW Management by NRW Task Force Team.
- Third activity is then it categories all teams/areas by NRW performance and focus on the weak teams/area.
- Fourth activity is about which it Monitor the internal implementation of NRW project.

9.1.7 Development of Effective Organization Structure

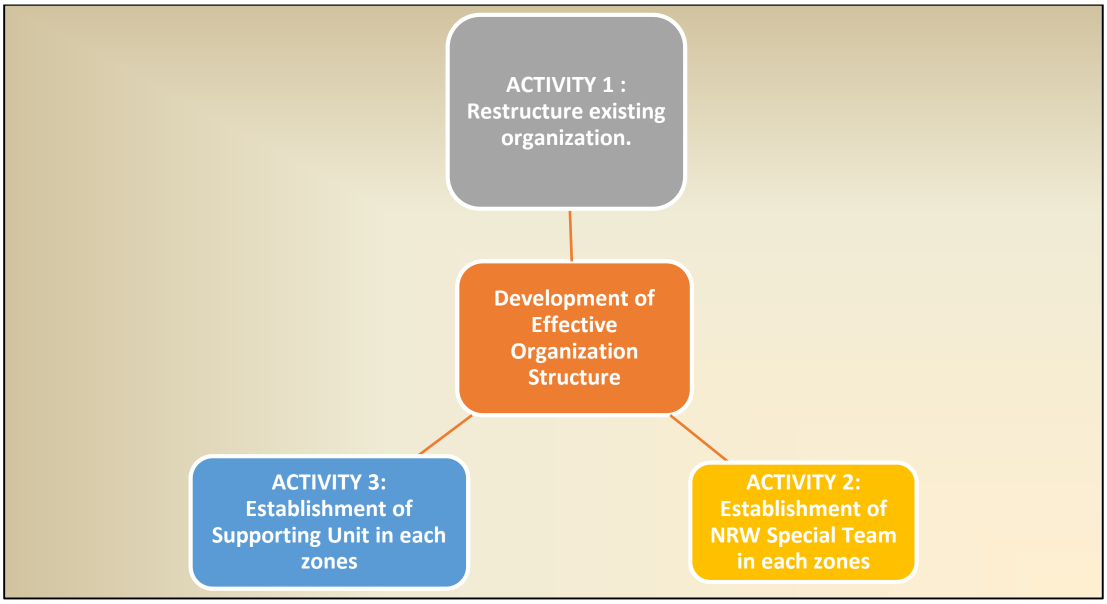


Figure 91: DEVELOPMENT OF EFFECTIVE ORGANIZATION STRUCTURE

The Development of Effective Organization Structure has,

- First activity is restructuring the existing organization.
- Second activity is then it Establishment of NRW Special Team in each zones.
- Third activity is that it Establishment of Supporting Unit in each zones.

9.1.8 Human Capacity Building in Managing NRW

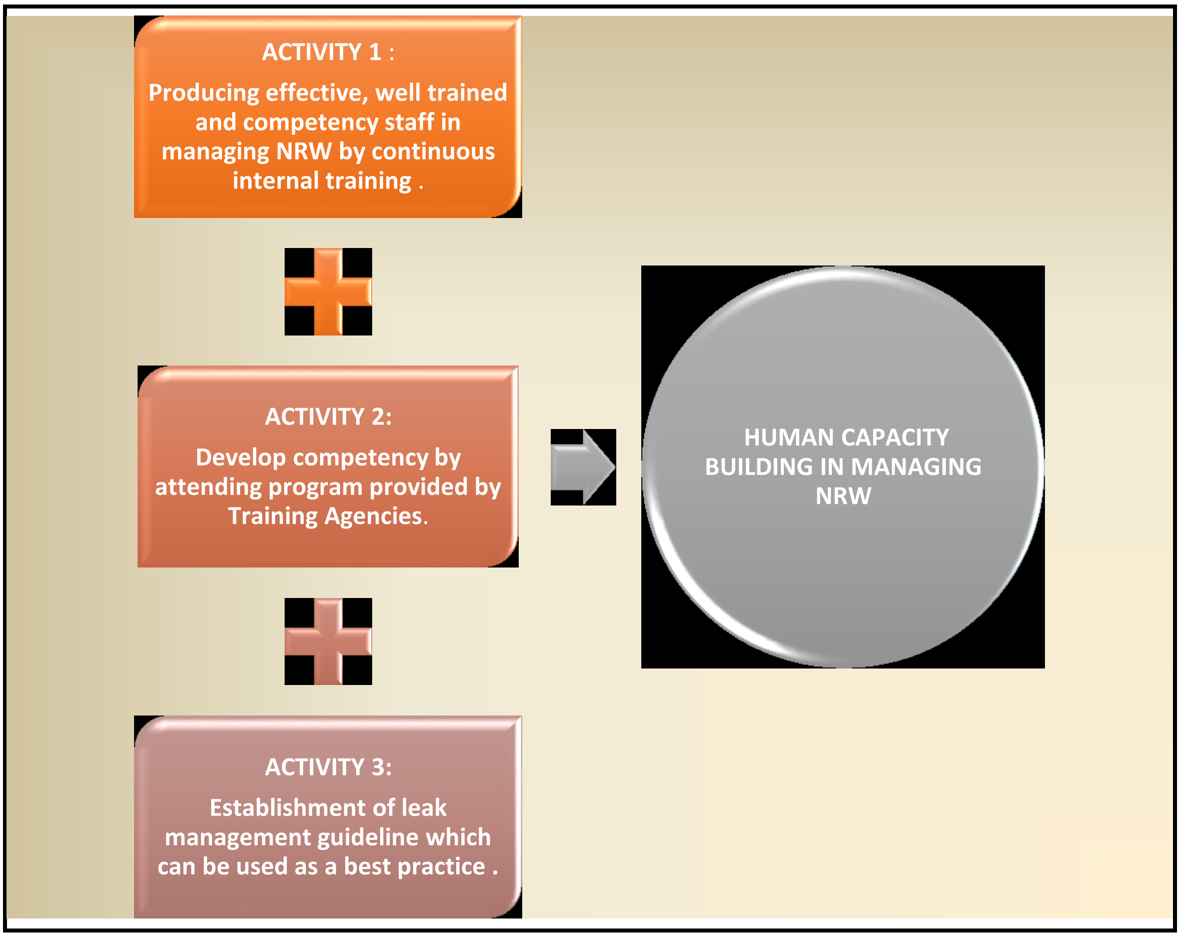


Figure 92: HUMAN CAPACITY BUILDING IN MANAGING NRW

The Human Capacity Building in Managing NRW

- First activity is producing effective, well trained and competency staff in managing NRW by continuous internal training.
- Second activity is developing competency by attending program provided by Training Agencies.
- Third activity after that it Establishment of leak management guideline which can be used as a best practice.

9.1.9 Improvement of Research Development and Innovation in Managing NRW

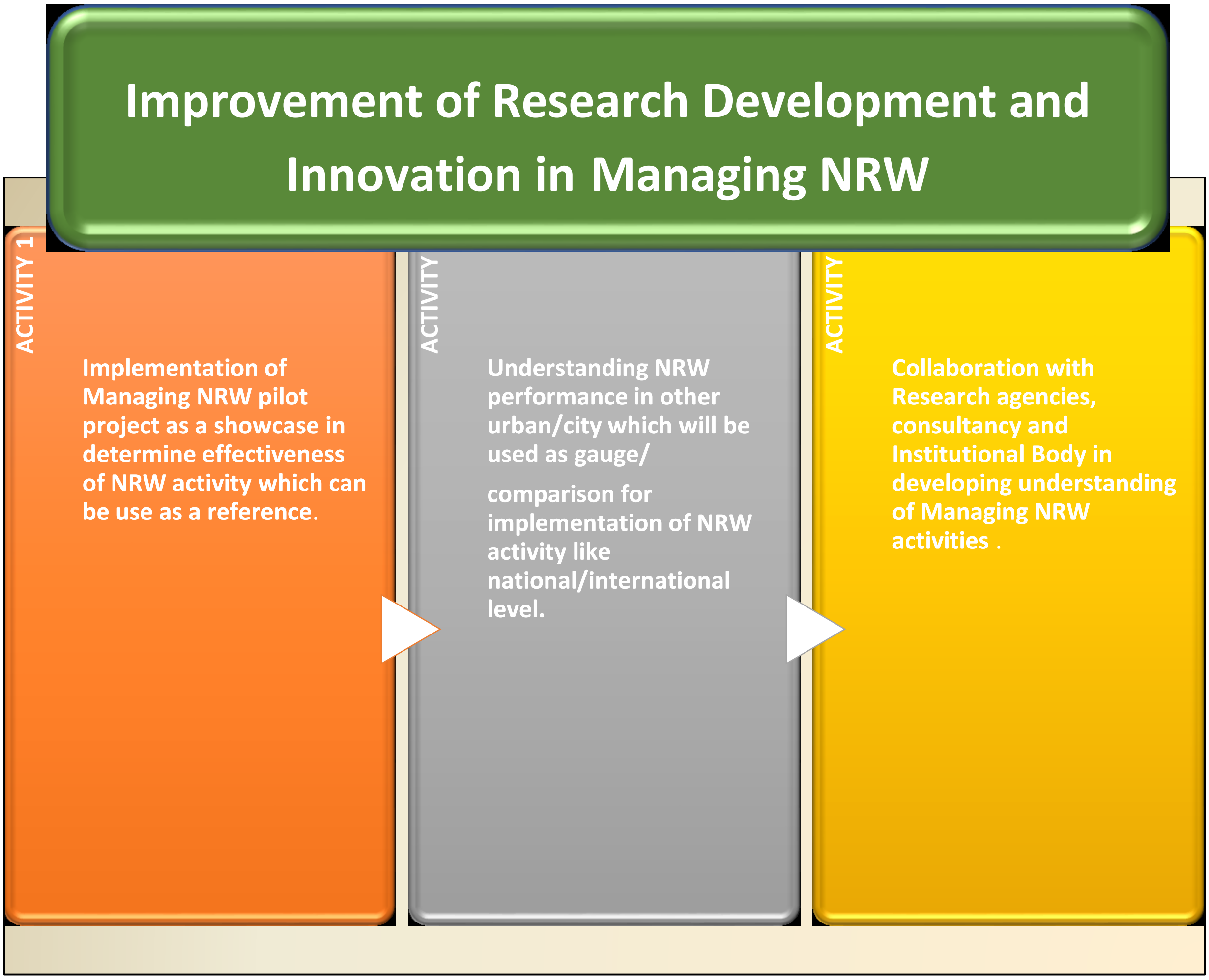


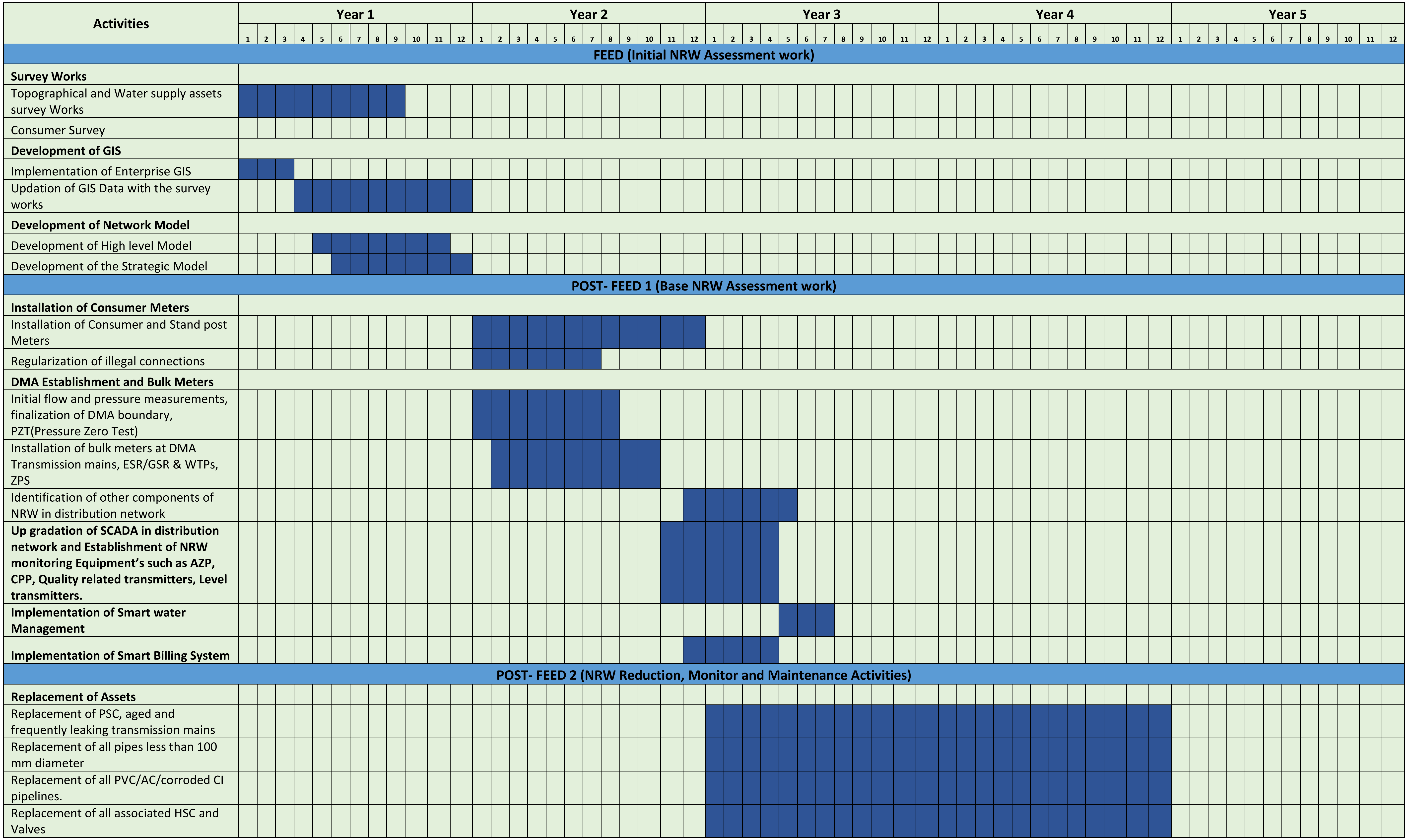
Figure 93: IMPROVEMENT OF RESEARCH DEVELOPMENT AND INNOVATION IN MANAGING NRW

The Improvement of Research Development and Innovation in Managing NRW has to

- First activity is implementation of Managing NRW pilot project as a showcase in determine effectiveness of NRW activity which can be used as a reference.
- Second activity is that understanding NRW performance in other urban/city which will be used as gauge/ comparison for implementation of NRW activity like national/international level.
- Third activity is then collaboration with Research agencies, consultancy and Institutional Body in developing understanding of Managing NRW activities.

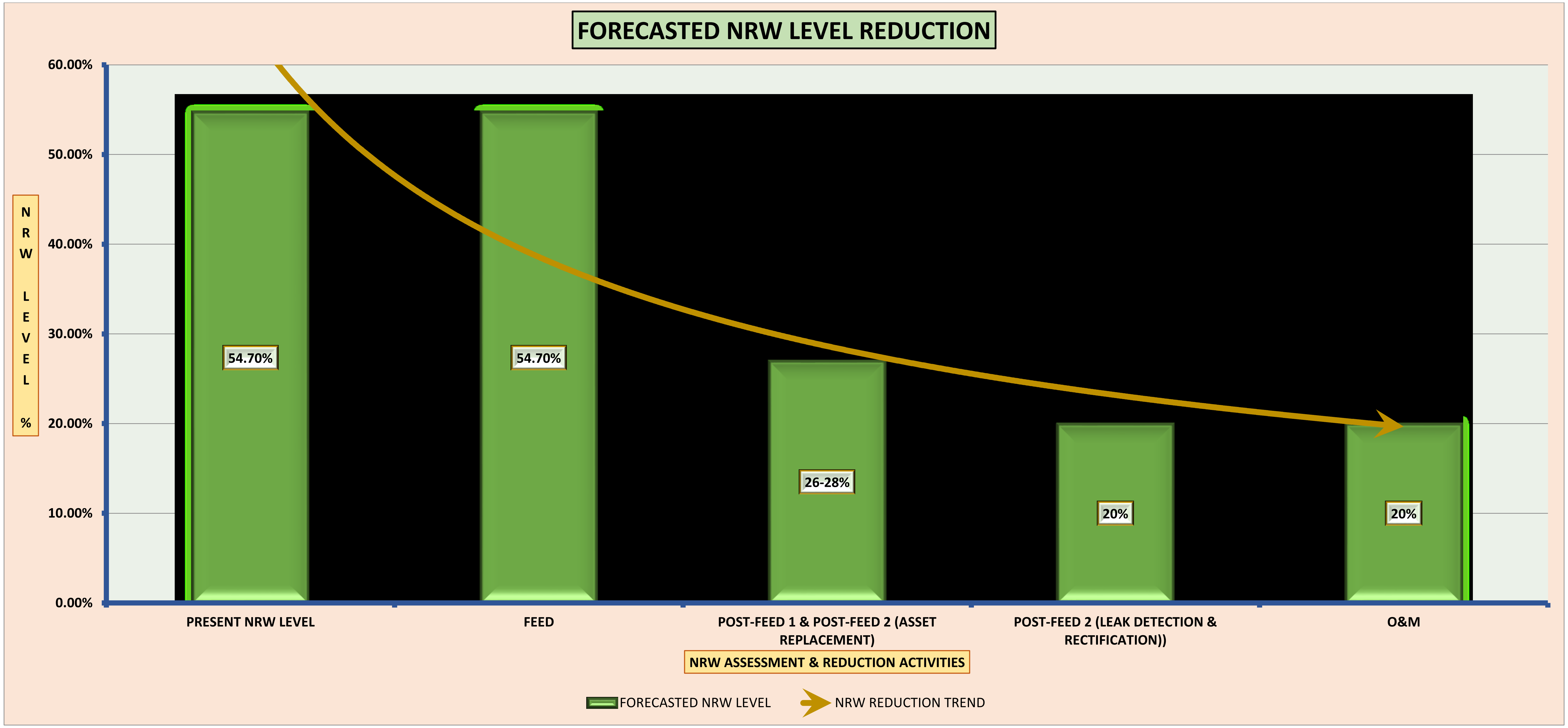
10 GANTT CHART FOR NRW REDUCTION

The NRW reduction plan prepared with consideration of As-Is situation of LMC water supply system and proposed methodology. NRW reduction plan proposed for 10 years that is 5 years – Project phase and 5 years- O&M of NRW phase.



Activities	Year 1												Year 2												Year 3												Year 4												Year 5											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Leak Detection & Rectification																																																												
Strengthening and Extension works																																																												
Extension of New distribution networks and Strengthening for distribution network improvements with new pipelines associated House service connections, consumer meters, valves etc.																																																												
Operation & Maintenance, Monitoring NRW level. Includes Leak detection & Rectification	**After 5th year (O&M period : 5 years)**																																																											

PROPOSED NRW REDUCTION FORECAST



PART-2

ASSUMPTIONS, COST ESTIMATES, PROJECT IMPLEMETATION & FUNDING OPTION

11 COST ESTIMATES & CONTRACT PACKAGES

11.1 Cost Estimates

Basis of Costing. The proposed cost of this NRW Reduction & Distribution network Improvement project in Lucknow City has been performed based on the following sources:

a. Validated derived quantity of the Proposed Improvements.
b. PWD Standard Schedule of Rates (SOR) of Lucknow.
c. Maharashtra State Standard Schedule of Rates (SOR)
d. Consultant's experience on similar projects.
e. For items not present in the aforementioned SOR, market rates have been taken.

Block rates have been determined for replacement/ rehabilitation of pipelines, Installation of EMF meters, Leak detection & rectification etc. for projecting the cost of each activity as these works are proposed to be put to bidding on turnkey basis as Lump sum.

11.2 Contract Packages

It has been observed that implementing agencies tend to split the work in small packages which results in too many contracts to be procured and monitoring of contract administration, work progress and quality control becomes cause of concern in addition to problem of coordination amongst different contractors.

Also the basic details of pipeline networks not available with LMC, hence it is proposed to have three packages to execute the project.

- Detail consumer survey, mapping and pipeline asset investigation, implementation & updation of GIS and preparation of hydraulic modelling (FEED).
- Turnkey contract for Design, procurement, execution of consumer meter installation, formation of DMA, Installation of Transmission flow meters and implementation, integration of SCADA.
- Performance based contract for Reduction of NRW and improvement of distribution network with O&M (monitoring & maintenance of NRW) for 5 years which including installation of DMA meters, replacement of pipeline, laying of new pipeline for improvement, Leak detection & rectification, updation of GIS & integration with SCADA, reduction and monitoring of NRW to targeted level. etc.
- The contract can be divided in to no of packages based on administration boundary, natural boundary etc.

11.3 Implementation Arrangements

Proposed Implementation Plan: - The whole project is proposed to be executed in a period of 60 months and 60 months for O&M of maintaining NRW level including 9 months for bidding and contract award.

Proposed Institutional Set- up: - LMC/JALKAL will be executing agency. The controlling officer is General Manager, LMC/JALKAL and supervising officer is Superintending Engineer, LMC/JALKAL. It would be appropriate to have two full time Assistant Engineers a dedicated for execution of this project and they should be assisted by supervision consultants.

11.4 GENERAL CONSIDERATIONS:

Below table lists all the overall general considerations,

Table 49: General Considerations for Lucknow

SN	Parameters	Unit	Quantity
1	Total area	Sq. Km	350
2	Forecasted Population of Lucknow for current year (2017)	No's	3094700
3	Total road length	km	3850
4	Total number of connections	No's	3,79,810
5	Total number of connections per DMA	No's	2500
6	Coverage of water supply connections (Excluding Govt. Buildings & Buildings, Consumers having own water resources)	%	71.37%
7	Total pipe-length	Km	2747
8	Total number of tube-wells	No's	644
9	Total number of Zonal Pumping Station	No's	38
10	Total number of ESR by LMC	No's	108
11	Total Number of WTPs	No's	3
12	Total Number of Units at AishBagh WTP	No's	5
13	Total Number of Units at Balaganj WTP	No's	2
14	Total Number of Units at 80 MLD WTP	No's	1
15	Total number of pumping stations at Goughat RW Pumping Station	No's	2
16	Total number of pumping stations at Balaganj RW Pumping Station	No's	1
17	Total number of pumping stations at Chinhat Lake RW Pumping Station	No's	2
18	Total number of pumping stations at AishBagh PW Pumping Station	No's	3
19	Total number of pumping stations at Balaganj PW Pumping Station	No's	1
20	Total number of pumping stations at 80 MLD PW Pumping Station	No's	1

SN	Parameters	Unit	Quantity
21	Total Approx. Existing PVC pipeline	Km	1923
22	Total Approx. Existing AC pipeline	Km	137
23	Total Approx. Existing CI pipelines	Km	412
24	Total Approx. Existing DI pipelines	Km	275

11.5 Cost Estimates of FEED

11.5.1 Estimated quantities of FEED

In this section we have tabulated the FEED activities as furnished below:

Table 50: Details for FEED Activities

SN	Capex items for Initial NRW assessment (FEED)	Unit	Quantity
1	GIS Data Centre Setup	Sq. Km.	350
2	DEM, 1 M Contour Generation including Stereo Pair Satellite Images	Sq. Km.	350
3	Conducting customer door to door survey	No's	5,32,170
4	water supply asset survey including type and condition assessment	Km	3,850
5	GIS mapping & Updation	Sq.km	350
6	High Level Strategic Hydraulic Modelling	Sq.km	350

Above set of implementation activities (FEED) will help to find out detailed information about Lucknow network, consumer details, assets and present hydraulic strength etc. which is very important for the NRW reduction activities to be able to take forward the POST-FEED activities such as Base NRW assessment, NRW reduction and monitoring (O&M) activities.

11.5.2 Estimated cost of FEED

Table 51: High level Capex cost for FEED

	Activities		UOM	Quantity	Rs in Crore
A	**Enterprise Level GIS Data Setup including**				
>	GIS Cell including ESRI software solutions and Hardware's		Set	01	
>	GIS Mapping & Updation		Sq.Km	350	
>	Conducting door to door survey		No's	532170	
>	Water Asset Survey including Type & Condition Assessment		Km	3850	
>	GPR survey for selected Area (to suit site condition)		LS		**22.08**
>	Extraction of 1M contour and DEM using Digital Globe Stereo pair Satellite Images		Sq.Km	350	
>	Establishment of precast concrete marker post at specified locations		LS		
B	**Development of Network Model & Real-time Network Optimization**				
>	Development of Network Model & Real-time Network Optimization		Sq.Km	350	
C	**Consumer Awareness Program & Capacity Development.**		LS		

SRN	CAPEX		Rs Inr	Rs Crore	PMC @5%	Contingency @3%	TOTAL in Cr
I	FEED Capex 1		**22,07,77,148**	**22.08**	**1.10**	**0.66**	**23.84**

Note: Above figures are exclusive of taxes and duties. The above cost was derived based on data validated by LMC and As-Is situation of Lucknow water supply system.

11.6 Cost Estimates of POST-FEED-1

11.6.1 Estimated quantities for Post FEED 1

Table 52: Details for Base NRW assessment (POST FEED 1)

SN	Capex items for Base NRW assessment (POST-FEED-1)	Unit	Quantity
1	Pressure Zero Test, Temporary Flow & Pressure Management, Survey of Existing Water Supply System	Sq.Km	350
2	Smart AMR/AMI Metering for Ground Water Tube wells	No's	644
3	Battery operated Electromagnetic Flow (EMF) Metering for Zonal Pumping Stations	No's	204
4	Battery operated Electromagnetic Flow (EMF) Metering for ESR	No's	216
5	AMI/AMR – UFM/EMF Consumer New Metering	No's	3,79,810
	15MM	%	3,72,214
	20MM	%	7596
	SCADA		
	Sensors		
5	**WTP**		
	Quality Monitoring Transmitters (Residual, pH and Turbidity)	No's	24
	Differential Pressure Transmitters	No's	8
	Controllers	No's	8
6	**Pumping Station (For Raw Water)**		
	Ultrasonic Level Transmitters	No's	5
	Controllers	No's	5
	Pressure Transmitters	No's	5
	Vibration System	No's	5
7	**Pumping Station (For Pure Water)**		
	Ultrasonic Level Transmitters	No's	43
	Controllers	No's	43
	Pressure Transmitters	No's	43
	Vibration System	No's	43
8	**Reservoirs**		
	Ultrasonic Level Transmitters	No's	108
	Controllers	No's	108
	Telemetry Pressure loggers for AZP & CPP for distribution networks	No's	576
9	EMF Meter for Distribution	No's	384
10	EMF Meter for Transmission and Ground water sources	No's	420
11	AMR/AMI meters for Ground water sources	No's	644
12	Smart water management and real time network optimisation	set	1
13	Smart water billing system	set	1

As explained in previous reports the budgetary cost and size & quantity such as (EMF meters for DMA's, Transmission lines, telemetry pressure loggers for DMA's) of POST-FEED 1 (Base NRW reduction activities) can be derived only after successful completion of FEED and DMA formation. However, the quantities have been derived and cost estimated based on selected DMAs, global assumptions & various experiences, the same has been validated by LMC as tabulated above. Also the mentioned quantities subject to change based on successful completion of FEED activities and DMA formation. The unit cost has been estimated based on reference as mentioned in section 10.1, the cost was calculated as tentative only, the cost can be varied based on location & current situation during execution of the project.

11.6.2 Estimated cost for Post FEED 1

Table 53: Capex cost for POST-FEED 1

	Activities		UOM	Qty	Rs in Crore
A	**Finalization of DMA Boundary :**				
>	Pressure Zero Test, Temporary Flow & Pressure Measurement, Survey of Existing water supply system & Finalization of boundary with confirmation.		Sq.km	350	16.80
B	**Supply & Installation of Bulk and Consumer meters**				
>	Supply, Installation of EMF meters along Transmission mains and Tube wells including road cutting, excavation, pipe cutting, pipe specials, sluice valves, air valves, Cabin box, back filling, disposal, Construction of RCC chamber, thrust blocks, Road reinstatement and integration with SCADA (Including all Diameters) as per requirement.		No's	1064	37.71
>	Supply, Installation of EMF meters along DMA's in distribution network including road cutting, excavation, pipe cutting, pipe specials, sluice valves, air valves, Cabin box, back filling, disposal, Construction of RCC chamber, thrust blocks, Road reinstatement and integration with SCADA (Including all Diameters) as per requirement.		No's	384	21.74
	Supply & Installation of AMI/AMR, UFM/EMF meters for existing consumer connections with all necessary fittings pressure transducers gate valves, strainers, Protection box, reinstatement and integration with SCADA as per requirement. 15mm & 20 mm diameters		No's	379810	441.12
C	Design, Procurement, Installation & Integration of SCADA with all pressure loggers, Quality, Level transmitters, Real time management platform etc. Including all fittings, controllers, communication accessories etc.		lot	1	93.55
D	Design, procurement and one time establishment of Smart Water Billing System including Consumer App, establishment & Integration with server		lot	1	2.00
	Total				**612.92**

SRN	CAPEX		Rs Inr	Rs Crore	PMC @5%	Contingency @3%	TOTAL in Cr
I	POST – FEED 1 Capex		6,12,92,07,041.66	**612.92**	**30.65**	**18.39**	**661.95**

Note: Above figures are exclusive of taxes and duties. The above cost was derived based on data validated by LMC and As-Is situation of Lucknow water supply system.

11.7 Cost Estimates of POST-FEED-2

11.7.1 Estimated quantities for Post FEED 2

As explained in previous reports the budgetary cost and quantity of POST-FEED 2 (NRW reduction, operation & maintenance of NRW level) can be derived only after successful completion of FEED. However, the quantities have been derived and cost estimated based on global assumptions & various experiences, the same has been validated by LMC as tabulated below. Also the mentioned quantities subject to change based on successful completion of FEED activities. Hence the consultant cannot assure the size & quantities as mentioned here. The unit cost has been estimated based on reference as mentioned in section 10.1, the cost was calculated as tentative only, the cost can be varied based on location & current situation during execution of the project.

Table 54: Estimated Quantity of POST-FEED 2

S. No	Diameter	Unit	Replacement / Rehabilitation of PVC/AC/CI Pipeline of Distribution	Capital work, expansion & Improvement/Strengthening	Total Quantity
Approx. Quantity of proposed Pipe line					
1	100 MM	Km	1673	716	2389
2	150 MM	Km	324	143	467
3	200 MM	Km	49	77	126
4	250 MM	Km	32	77	109
5	300 MM	Km	39	88	127
	Sub Total	km	2117	1101	3218
Approx. Quantity of proposed House service connection replacement					
1	15 mm	No’s	227050	0	227050
2	20mm	No’s	4633	0	4633
	Sub Total	No’s	231683	0	231683

11.7.2 Estimated cost for Post FEED 2

Table 55: Cost Estimates of POST-FEED-2

A	Replacement/Rehabilitation of pipeline network		UOM	Qty	Rs in Crore
>	Supply, laying, jointing, testing & commissioning of DI K-9 pipe or required diameter of AC/PVC/CI pipeline replacement as per site condition, including road cutting, excavation, associated DI K12 pipe specials, associated valves, back filling, disposal, and road restoration as per requirement.		Lot	1	864.56
B	**Improvement/Strengthening of distribution network**				
>	Supply, laying, jointing, testing & commissioning of DI K-9 pipe or required diameter of AC/PVC/CI pipeline replacement as per site condition, including road cutting, excavation, associated DI K12 pipe specials, associated valves, back filling, disposal, and road restoration as per requirement		Lot	1	507.80
C	**Supply, laying, jointing, testing and commissioning of consumer service connections making bore holes for fix service connection including DI strap saddle, elbow, compression joint, PVC ball valve, casing GI pipe for drain crossing, road cutting, excavation, back filling, disposal, and road reinstatement as per requirement. For 15 mm & 20 mm diameter**		No's	231683	93.37
D	**Design, Supply, Installation & Integration of SCADA of pressure reducing valves (PRVs) with Including all fittings, controllers, communication accessories, construction of chamber etc.**		Lot	1	1.37
E	**Leak detection and rectification of pipe line leakages with necessary fittings, road cutting, excavation, back filling, disposal and restoration.**		lot	1	7.33
F	**Periodical Reports**		lot	1	1.00
G	**Monitoring & Maintenance of targeted NRW level for 5 years**				141.03
	Total Cost POST - FEED-2 Capex				**1616.46**

SRN	CAPEX		Rs in INR	Rs Crore	PMC @5%	Contingency @3%	TOTAL in Cr
I	POST - FEED-2 Capex		**16,16,45,50,449**	**1616.46**	**80.82**	**48.49**	**1745.77**

Note: Above figures are exclusive of taxes and duties. The above cost was derived based on data validated by LMC and As-Is situation of Lucknow water supply system.

11.8 OVER ALL APPROX. BUDGETARY COST OF NRW REDUCTION PROJECT

Estimated Over all budgetary cost for NRW reduction		
S. No	**Description**	**Budgetary cost in Crore**
A	Approx. Cost of Initial NRW assessment work (FEED)	22.08
B	Approx. Cost of Base NRW assessment work (POST-FEED 1)	612.92
C	Approx. Cost of NRW reduction work (POST-FEED 2) including NRW monitoring for 5 years	1616.46
E	**Sub Total**	**2251.45**
F	Design Supervision and third party inspection (PMC) @ 5% of (E)	112.57
G	Physical contingencies @ 3% of (E)	67.54
H	Provision for Institutional Development @ 1% of (E)	22.51
I	Provision for Environmental Mitigation @ 1% of (E)	22.51
J	Provision for Incremental Administration @ 1% of (E)	22.51
	Grand Total	**2499.11**

Note: Above figures are exclusive of taxes and duties. The above cost was derived based on data validated by LMC and As-Is situation of Lucknow water supply system.

- The Cost for Source sustainability and calculation of Capacity for ESR/GSR for future demand as well as new augmentations are not a part of NRW reduction activities, hence the quantity and cost didn't consider in this report. The same assessment shall be carried out by LMC/ JALKAL in future based on at present situation.
- Cost for installation of consumer meters and one-time implementation of smart water billing considered in this report, hence periodic billing and collection shall be carried out by LMC/JALKAL.
- After completion of project and maintenance & monitoring of NRW, LMC/JALKAL to be carried out the NRW reduction & monitoring.
- LMC/JALKAL shall develop the NRW cell to monitor the project.

12 PROPOSED AND FINALIZED OPTIONS FOR IMPLEMENTATION OF NRW PROJECTS

12.1 PROPOSED NRW IMPLEMENTATION OF LMC

12.1.1 Option A

Jal Kal Sansthan has been active and has expert personnel on the board knowledgeable in the water segment. There is a need to setup and deploy NRW core team taking responsibility for implementing the reduction interventions for a period of around 5 years.

12.1.2 Advantages

- Lot of in-house knowledge at disposal
- More power over administration and decision-making capabilities
- Expertise built now will make the entire system sustainable for long term
- Updated records on the network map and knowledge of the system inside out will equip the staff to handle issues more efficiently

12.1.3 Risks

- Staff has inertia to change daily course of action and take initiatives out of their profile
- Reluctance to accept any sort of change in work, hierarchy, re-structuring, etc.
- Low financial freedom on the management decisions and budget sanctioned
- Measuring performance on the basis of target NRW is a challenge as the staff is not used to be scaled upon that

12.1.4 Option B

The team could be structured so as to have 2 arms – one is the management team which is a private contractor and other is the implementation team which is in house Jal Kal staff. The staff needs to be handle all the field work with all decisions around identification of proper instruments, timelines and plan. The management team will monitor the overall program, evaluate performance of the interventions and take appropriate measures for effective delegation and roles.

12.1.5 Advantages

- Skillsets and expertise with the right team will lead to effective implementation
- Relatively higher financial and operational stability
- Good technical competence and experience in project implementation
- Will ensure overall service improvement in the entire value chain from source to customer

12.1.6 Risks

- Distribution of responsibilities may lead to conflicts for overlapping and collaborative working areas
- Expensive on the consultants and directors working on the management board as per the contract
- Local environment might not be conducive enough for the change and technical advancements

12.1.7 Option C

Hybrid Annuity Model (HAM) is a mix of BOT Annuity and EPC model. Here, first 40% payment or as per the adjustment, specific % payment is made as fixed amount in five equal instalments whereas remaining % is paid as variable annuity amount after the completion of the project depending upon the value of assets created and performance exhibited.

Under HAM, the toll collection is done by the government and later the variable annuity is being paid to the implementing agency in instalments for 15-20 years.

12.1.8 Advantages

- The implementing agency will be accountable for achieving the performance i.e. NRW reduction targets
- Equity portion is narrowed down to 10-15% of the project cost as against 20-25% in case of BOT (annuity) projects
- Adopts rational approach for allocation of risks between PPP partners – the government and the private partner i.e. the develop / investor
- Gives enough liquidity to the private partner / developer

12.1.9 Risks

- Difficulties faced in getting money from lenders i.e. banks who are not that comfortable
- Long periods for recovery of remaining amount in the form of variable annuities
- Over ambitious targets like 15% make be difficult to achieve in the local operating environment.

12.2 PROPOSED FUNDING OPTIONS FOR NRW REDUCTION PROJECT

Sources of funding for ULB:

There are private institutions like banks, lending companies, public institutions giving grants like ADF, etc.

12.2.1 Municipal bonds

Municipal bonds are debt instruments issued by municipalities or other state agencies which use the money to build schools, water supply systems, sewer systems, and other projects for public good. When someone purchases a municipal bond, they are lending money to a state or local government entity, which in turn promises to pay a specified amount of interest and return the principal amount on a specific maturity date. Municipal bonds can be of two types, namely:

12.2.2 Revenue Bonds

Revenue bonds are bonds supported by the revenue from a specific project, such as a water supply project or a sewer systems project. Such bonds finance income-generating projects and are secured by a specified revenue source. For example, if a revenue bond is issued to upgrade a water supply network, the water charges collected from users would be used to pay off the bond.

12.2.3 General Obligation Bonds

General obligation bonds are issued in the belief that a municipality will be able to repay its debt obligation through taxation or revenue from projects. Unlike revenue bonds, general obligation bonds can be paid through a variety of tax sources. These therefore may not be for specific revenue-generating projects.

By taking advantage of the measures adopted by the central government, the 14th Finance Commission, and SEBI, municipalities will be able to fund infrastructure projects in their cities, and improve service delivery. Municipalities can raise money in the form of debentures that are traded across stock exchanges and use the money to invest in projects on water supply, storm water drains, roads and other public infrastructure. To successfully raise money from bond markets, municipalities must ensure that their accounts are prepared on time, audit of accounts is carried out by an independent agency, financial and operational data is made public, and that they comply with all eligibility requirements put forth by SEBI and their state governments. Additionally, municipalities can comply with disclosure standards adopted by the private sector to boost investor confidence and bond subscriptions. Example of municipal bonds based funding in Indian cities is tabulated below,

Table 56: Example of Indian cities who received funding from municipal bonds

City	Issue Year	Issue Size (Rs. Crore)	Purpose
Ahmedabad	1998	100.00	Water Supply and Sewerage
	2002	100.00	Water Supply and Sewerage
	2004	58.00	Water Supply, Storm water drainage, roads and bridges
	2005	100.00	Roads and water supply
Nagpur	2001	50.00	Water Supply
	2007	21.20	Water Supply and Sewerage

Few eligibility criteria for issuer are listed below,

- The municipality (issuer) should be allowed to raise money under the laws that govern it
- The municipality should not have negative net worth for the last three financial years
- The municipality should not have defaulted in repayment of debt securities or loans

12.2.4 Pool finance development fund

Pooled financing may be undertaken by the ULBs when their creditworthiness is not found very sound on a standalone basis. Under such a scheme, funds raised from bonds are extended as credit by the issuers (usually, called bond banks) to more than one borrower (in this case, more than one ULB). These borrowers are not necessarily related among themselves. It is a process of credit enhancement for smaller ULBs. However, pooled financing scheme needs to be combined with project design and management expertise. It also requires enhancing the efficiency of ULBs to meet the pre-conditions of a bond issue, such as accounting, management information systems and procurement reforms. In the case of pooled financing in India escrow accounts were structured at the ULBs for debt servicing, which collected the deposit (one-time) and tariff (monthly) charges from various projects. Proceeds from the bond issue are used for funding various projects. Thus, the bonds were like revenue bonds. Additional credit enhancements included creation of debt service reserve funds at each of the ULBs where the tax and other revenue collections of the ULB are remitted. Further, in the case of a few issues, provision for state finance commission devolutions (SFCD) intercept was made, under which a shortfall in the payments into the ULBs' debt servicing accounts would be made up from future devolutions from the State Finance Commission that accrue to the ULBs. Again, a Bond Service Fund, in which state funds are held in the form of liquid securities, may be used by the pooled fund if the afore-mentioned means of debt servicing is not succeeded.

Table 57: Indian cities who received funding through pool finance development fund

City**	Issue Year	Issue Size (Rs. Crore)	Purpose
Tamil Nadu	2002	30.20	Water and Sanitation
	2008	6.70	Water and Sanitation
	2010	83.19	Water and Sanitation
	2012	51.00	Water and Sanitation
	2013	51.00	Water and Sanitation
Karnataka	2005	100.00	Water supply component of a greenfield project for 8 ULBs, Greater Bangalore Water Supply and Sanitation project (GBWASP)

**Municipal Bonds – Janaagraha Centre for Citizenship and Democracy, June 2015 Report

12.2.5 Public Financing Institution/Bank Finance

These Institutions provide short term, medium term and long-term credit. Banks are permitted to finance SPVs, registered under the Companies Act, set up for financing infrastructure projects.

12.2.6 Multilateral Financial Institutions

A Multilateral Financial Institution (MFI), also known as Multilateral Development Bank (MDB) is an institution, created by a group of countries, that provides financing and professional advising for the purpose of development. MDBs have large memberships including both developed donor countries and developing borrower countries. MDBs finance projects in the form of long-term loans at market rates, very-long-term loans (also known as credits) below market rates, and through grants.

Some of the MFIs are International Monetary Fund (IMF), World Bank, European Bank for Reconstruction and Development (EBRD), European Investment Bank (EIB) as well as the Global Environmental Fund (GEF).

Table 58: Example of Indian cities who received funding from MFI

Funding agency	City	Issue Year	Issue Size (Rs. Crore)	Purpose	Interest (%)	Repayment/Deferment Period (Years)
ADB[24]	Kolkata	2011	1784.40	24/7 Water Supply and Improved Sanitation	NA	NA
World Bank[25]	Hubballi-Dharwad	2016	662.60	Karnataka Urban Water Supply Modernization Project (KUWSMP)	NA	NA
JICA[26]	Bisalpur-Jaipur	2004	506.16	Bisalpur- Jaipur Water Supply Project	1.3	30/10
	Bangalore	2005	2388.30	BWSSB	1.3	30/10

The criteria are defined specifically based on the economic conditions of a country. The countries are usually placed in buckets like – high income, middle income and low-income countries. The lending rates, terms and contractual conditions then vary as per the financial and economic health of the country. Few details on MFIs as found through secondary research are tabulated below,

[24] www.adb.org
[25] www.worldbank.org
[26] www.jica.go.jp

Table 59: Key Details of various MFIs

MDB[27]		Instrument	Maturity (years)	Grace period (years)	Interest and other features	Eligibility criteria	Who can borrow
World Bank	IDA (International Development Association)	Regular credit	38	6	No interest. 0.75 % service charge (Special Drawing Rights (SDR)).	Under the IBRD Articles of Agreement, a country must first join the International Monetary Fund (IMF).	Economies are divided into IDA, IBRD, and blend countries based on the operational policies of the World Bank. Countries with low per capita incomes and lacking the financial ability to borrow from IBRD, can borrow from IDA. Blend countries are eligible for IDA loans but are also eligible for IBRD loans because they are financially creditworthy.
		Blend	25	5	1.25% interest. 0.75 % service charge (SDR).		
		Hard-term lending	25	5	1.08% interest. 0.75 % service charge (SDR).		
	IBRD (International Bank for Reconstruction and Development)	Flexible loan, variable and fixed spread and development policy loans	8 to 15/20	N/A	6-month Libor, plus contractual spread of 0.5%. Front-end and commitment fee of 0.25% each.		
		Special development policy loan	5 to 10	3 to 5	6-month Libor plus a minimum of 2%. Front-end fee of 1% of the principal loan.		
ADB		Libor-based loans	Varies	N/A	Floating 6-month Libor rate; contractual	Members of UNESCAP and other regional	

[27] Multilateral Development Banks – A Short Guide, Dec 2015

MDB[27]		Instrument	Maturity (years)	Grace period (years)	Interest and other features	Eligibility criteria	Who can borrow
	ADB (Asian Development Bank)				spread and maturity premium fixed.	countries and non-regional developed countries which are members of the UN.	Public and private sector – 83% of disbursements in 2014 were to sovereign lenders.
		Local currency loan	Varies	N/A	Floating or fixed rate, contractual spread and maturity premium fixed.		
	ADF (Asian Development Fund)	Group A (ADF-only): Project loans	32	8	1% during grace period; 1.5% beyond grace period. Equal amortisation; no commitment fee.		
		Group A (ADF-only): Programme loans	40	8	1% during grace period; 1.5% beyond grace period. Equal amortisation; no commitment fee.		
		Group B (Blend)	25	5	2%. Principal repayment at 2% per year for the first 10 years after the grace period and 4% per year thereafter; no commitment fee.		

MDB[27]		Instrument	Maturity (years)	Grace period (years)	Interest and other features	Eligibility criteria	Who can borrow
		Emergency assistance loans	40	10	1%. Principal repayment at 2% per year for the first 10 years after the grace period and 4% per year thereafter; no commitment fee.		

12.3 FINALIZED NRW IMPLEMENTATION OPTIONS BY LMC

Further the discussion with Lucknow Municipal corporation and JALKAL, it has been finalised that the NRW implementation will be executed in three phases FEED, POST-FEED 1, POST-FEED 2. And the finalized implementation as tabulated below.

Table 60: Finalized NRW project implementation options

Project Phases	Finalized Implementation option	Remarks
FEED **(Initial NRW Reduction activities)**	Activity and BOQ based Contract	
POST-FEED 1 **(Base NRW Reduction activities)**	Turnkey based Contract	Activities of POST FEED 1&2 can be clubbed and executed together as per site situation & requirements
POST-FEED 2 **(NRW reduction & Monitoring, Maintenance up to 5 years)**	Performance based Contract	

12.4 FINALIZED NRW FUNDING OPTIONS BY LMC

The Finalized funding options as tabulated below: -

Table 61: Finalized funding options

Project Phases	Finalized Funding options	Remarks
FEED **(Initial NRW Reduction activities)**	• 14th Finance Commission • Urban Infrastructure Fund • Performance grants from 14th Finance commission • Revolving fund from the state Govt. • External development charges of the LDA/UPAVP • Central funds from CA/ACA	
POST-FEED 1 **(Base NRW Reduction activities)**	Multilateral Financial Institution (MFI) or Multilateral development Banks (MDB)	Activities of POST FEED 1&2 can be clubbed and executed together as per site situation & requirements
POST-FEED 2 **(NRW reduction & Monitoring, Maintenance up to 5 years)**	Multilateral Financial Institution (MFI) or Multilateral development Banks (MDB)	

PART-3 ANNEXURES

DATA CONSTRAINTS FOR NRW ASSESSMENT

Details on following are not available–

SN	Data Constraints	Description	Remark
	GIS	Enterprise GIS not available	Required to understand the network and modelling. As well as estimation of NRW reduction budget and tariff rationalization.
1	Water supply assets details	Details like age of water assets reservoirs	This required analysing asset condition and percentage of replacement. As well as estimation of NRW reduction budget and tariff rationalization.
2	Pipeline Network	Pipe line details like diameter, material, age and alignment , connectivity details not available	This required analysing asset condition and percentage of replacement. As well as estimation of NRW reduction budget and tariff rationalization.
3	Night supply (MNF)	MNF condition not available due to intermittent supply	This is required for analyse the actual real losses by bottom up method.
4	Billing Data – Zones 4, 5 and 6	Missing / unclear information available on number of connections, arrears demand, present demand and total demand	This is required to do analysis on billing collection
5	ARV Clarification – for '0' ARV	There is no clarity on '0' values for ARV in the ARV data shared. As per the model, '0' ARV can happen in following 3 cases – a. Case 1: The property has double connection and consumer is paying bills as per ARV for the first connection and as per minimum rate for the second one. b. Case 2: ARV valuation is not yet rated by LMC but, connection exists. c. Case 3: Connection is not there in the property but comes under the radius of 100 meters. from municipality water distribution line for that pocket.	This is important to decipher the '0' ARV records from the ARV data. Based on this, we will understand the billed amount in each zone. With this metering and billing will be covered.

		Also, no information on whether the property has area <= 13 sq. m. or above 13 sq. m. based on which the bill for water is either Rs. 588 or Rs. 735 respectively	

12.5 Pipeline Details as per survey

12.5.1 Transmission

Transmission pipe line details from raw water to WTP inlet are tabulated below,

Table 62: Raw Water Transmission Pipeline Details[28]

WTP	RW Transmission Pipeline Material	RW Transmission Pipeline Length (kms)	RW Transmission Pipeline Diameter (mm)
AishBagh WTP	MS	12	1300
	PSC	14	1200
	MS	11	675
	MS	14	500
Balaganj WTP	MS	1.5	1200
	MS	1.5	900
80 MLD WTP	MS	7	1300
Total length up-to WTP		**61**	

Table 63: DMA existing Pipeline details as per survey

[28] Ceinsys team in consultation with Jal Kal, Lucknow

Pipeline Details of selected DMAs based on Actual Survey Undertaken by CEINSYS

S. No.	Diameter mm	Type of pipe Material	Indira Nagar	Gomti Nagar	Rajajipuram	Total
		1	2	3	4	
1	75	PVC	4,546.57	4,358.96	9,650.97	18556.50
2	100	PVC	2,284.49	3,361.82	3,662.42	9308.72
3	125	PVC	683.71	327.39	-	1011.10
4	125	CI	-	867.97	-	867.97
5	150	PVC	-	1,977.71	-	1977.71
6	150	AC	-	-	3,016.58	3016.58
7	150	PVC	-	683.80	-	683.80
8	200	AC	350.99	1,123.54	-	1474.53
9	200	MS	-	-	244.37	244.37
10	250	AC	86.06	115.91	-	201.97
11	250	CI	-	-	947.63	947.63
12	300	AC	292.38	173.98	-	466.36
Total Length in meter			8244.19	12991.07	17521.97	38757.23
Total Length in Kilo meter			**8.24**	**12.99**	**17.52**	**38.76**

12.6 POPULATION PROJECTION WORKINGS

Table 64: Population Projection for Year 2021

All figures are in numbers				
Year	Population – LMC	Increase	Incremental Increase	Percentage Increase
1971	774644	-	-	-
1981	947990	173346	-	22.38%
1991	1619116	671126	497780	70.79%
2001	2185927	566811	-104315	35.01%
2011	2817105	631178	64367	28.87%
	Average Values	510615.25	152610.6667	44.89%
	Geometric Mean			0.355731332

	Arithmetic Increase	Geometric Progression	Incremental Increase	Graphical*
2021	33,27,720	381,9,237	34,80,330.917	34,48,283

12.7 CASE STUDY 1 – MANILA (RANHILL)

Manilla Philippines

Manilas department for water supply MWSS[29] was losing 1,000 MLD from physical leaks and pilferage in 1996. At 150 litres per capita per day (LPCD), the 1,000 MLD could have served around 6.7 million people. This amount to 1 billion plastic bottles of soda (1-liter size) being spilled every day. Almost two-thirds of water supply was lost daily. It was imperative for the water utility to work on Non-Revenue Water.

The reasons were identified as below:

- System Losses
- Non-Existent Wastewater management
- Low Tariffs
- Maintenance Issues
- Low Productivity

To improve and expand the availability and coverage of water in Metro Manila, the government initiated reforms of water services through the implementation of the public-private partnership (PPP). The company's NRW reduction programs across Metro Manila's East Zone and the various subsidiaries incorporate a mix of technology and community partnership solutions to address losses in the water distribution system from pipe leaks and pilferages.

Key Features of the PPP model:

- The Ayala Brand of Leadership
- Developing Future Leaders: Cadetship Training Program
- Minimization of bureaucracy
- Corporate volunteerism
- Performance-based results
- Establishment of the Customer Care Centre
- Replacing old pipes and laying 4,611 km of new lines
- 36-month instalment-program for low-income communities
- Conducted gathering and provided updates on its operations in the area and solicited feedback from community leaders

Following the new concept of decentralization and Manila Water's implementation there was gradual reduction of NRW levels from 63% during the start of the concession, to 43% in 2004, 40% in 2005, 30% in 2006, and finally to an **all-time low of 11%** in 2010.

[29] https://www.adb.org/sites/default/files/publication/42755/tap-secrets.pdf

With reduced NRW, there was a visible increase in water supplied to customers. This has undoubtedly enabled Manila Water to raise water service to world-class levels and expand the network to provide greater access to 24x7 water supply. This is equivalent to **99% 24-hour coverage**, or around 3 times more customers served.

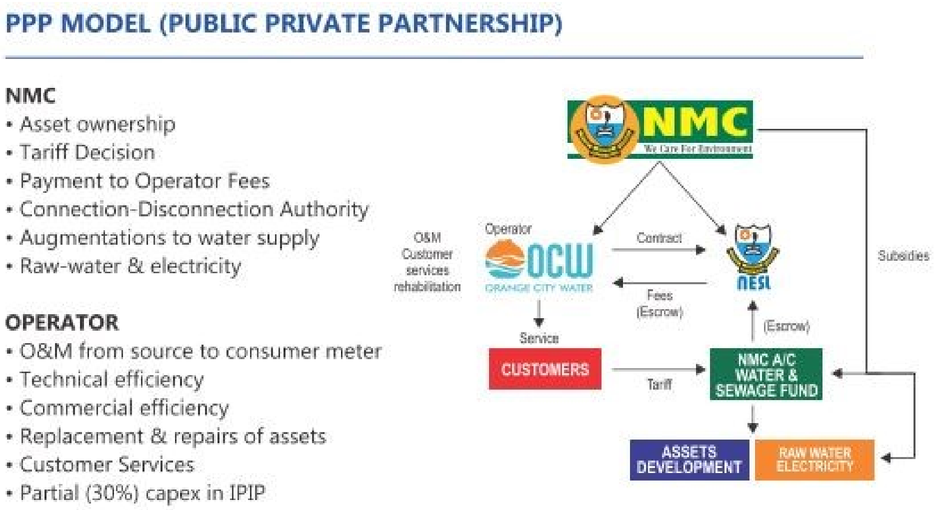
12.8 CASE STUDY 2 - NAGPUR

Nagpur, Maharashtra

Nagpur is the 3rd largest city in Maharashtra state with a population of over 2.5 million people. It became the first city of its size in the country to outsource its water supply to a private operator under the PPP model for 25 years.

NMC (Nagpur Municipal Corporation) is responsible of providing water supply services to the city of Nagpur. The total water supply to the city was 500 MLD per day through nearly 225 thousand connections in 2008, now water supply capacity upgraded to 765 MLD and about 350 thousand connections in 2015. The distribution network consists of over 3000 Km of pipe line network.

-



The existing situation in 2008 had intermittent water supply with ma areas getting alternate day supply & Non-Revenue Water was well above 50%**.** It was imperative to reduce the NRW of Nagpur city. The steps taken by NMC are stated below:

Because of PPP model, there was tremendous increase in customer satisfaction and consumer base.

- Entire zone experienced improve pressures eliminating the use of booster pumps
- Coverage improved with an incremental **5000 connections** being given in slum households
- Billed water volume increased from **22 MLD to 33 MLD**
- NRW reduced from **50 % to 38 %** and was attributed to reduction in illegal connections and improved accuracy of meter reading.

Contractor

The contract was awarded to a private contractor – a 50:50 joint venture SPV company incorporated with equal equity stake of a private limited company and water expert global company

PPP Model

The private entity brought 30% of the investment of the estimated project cost, 70% was brought by the public entity's contribution under MNURM + 100% escalation. The project was supposed to be operative for 25 years of O&M including 5 years of capital rehabilitation.

Scope of work

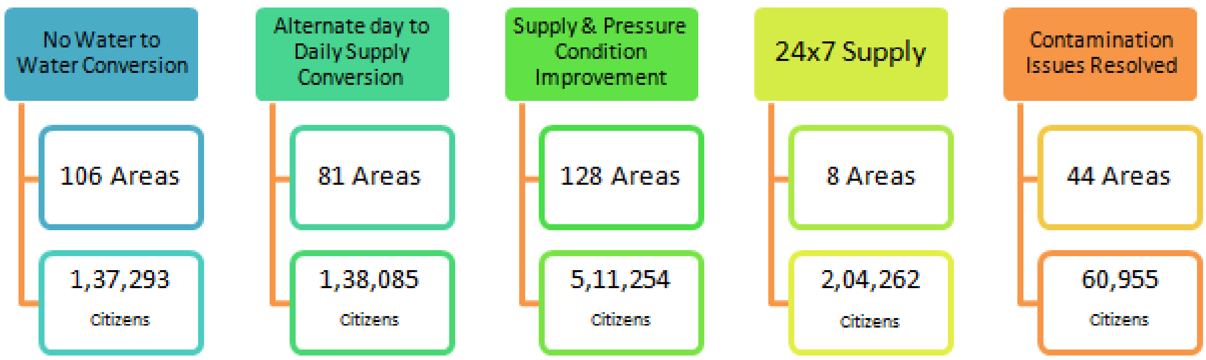
The project covered management of the entire water cycle from production, treatment (657 MLD), transport (2100 km of network), storage and delivery to the last point of usage i.e. the customers tap. This involves replacement of more than 3,00,00 HSC, rehabilitation of treatment facilities, service reservoirs and pipeline.

Customer-centric Approach

24×7 call centre for customer grievances, photo billing, online billing and customer service centre to be made open for all 7 days of the week

Performance

By the end of 3 years, total 10,51,849 citizens benefitted significantly. Under Rehabilitation: 480.00 km pipe line laid; 96,059 connections replaced.



Below is the snapshot of key strategies adopted to achieve NRW reduction target.

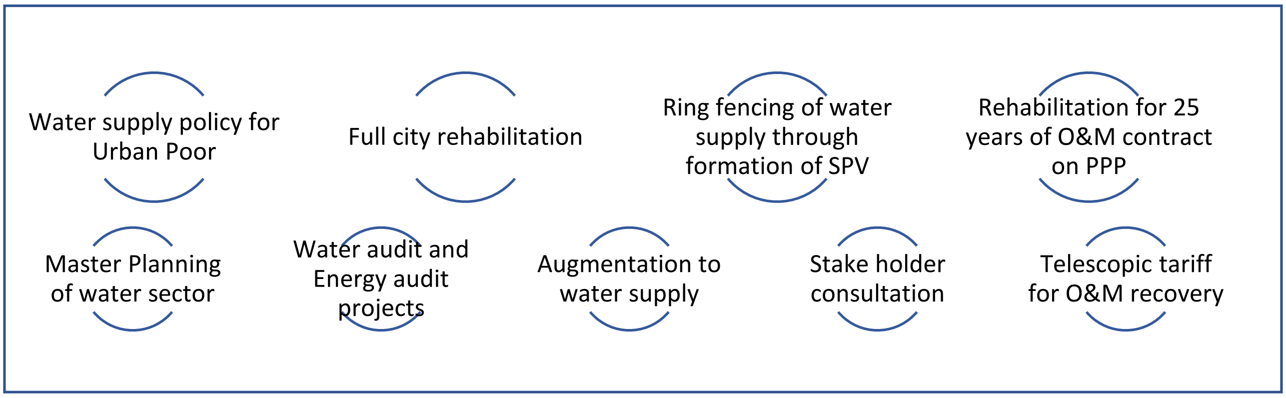
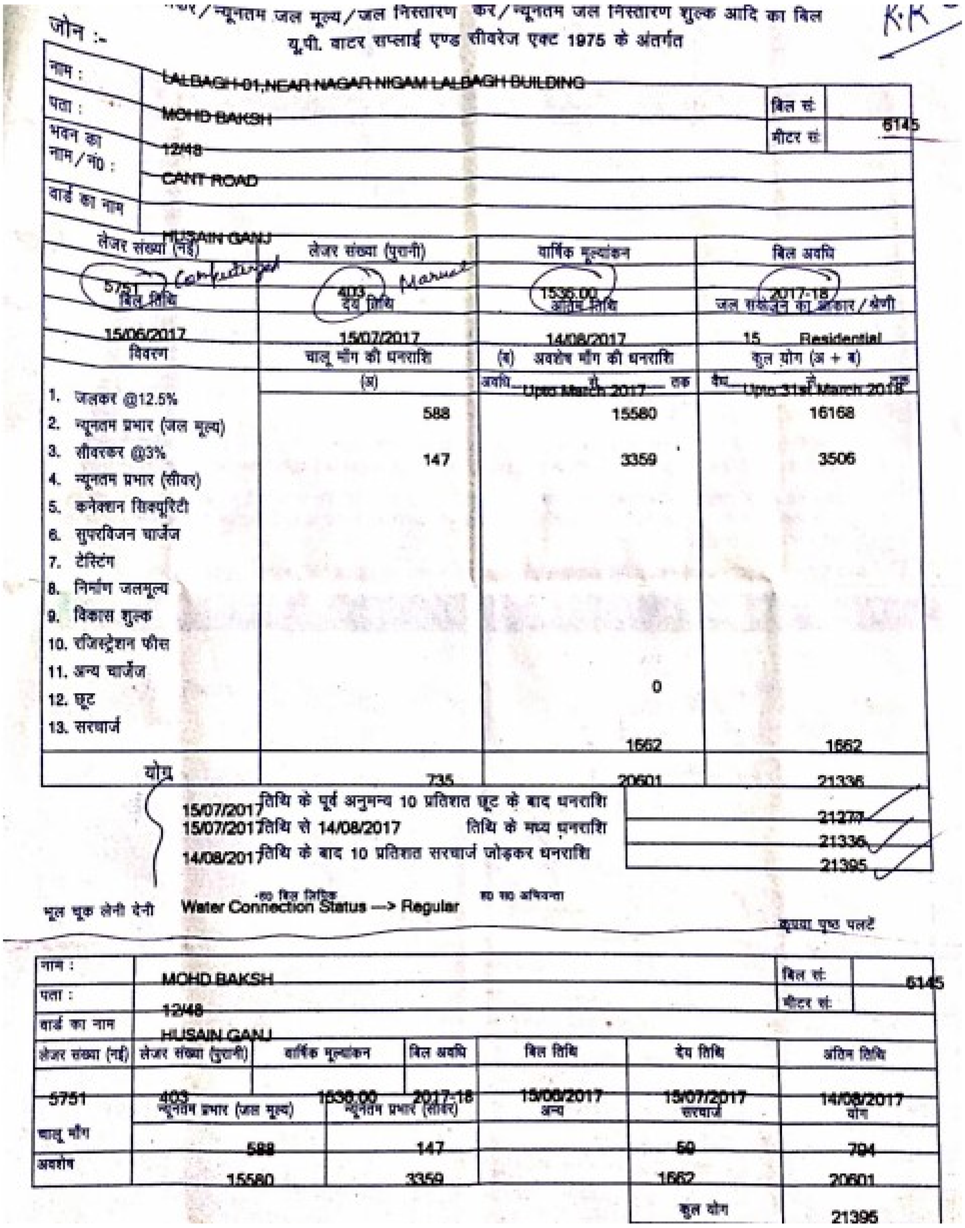


Figure 94: Strategy Map for Nagpur NRW

12.9 SAMPLE WATER TARIFF



जौन :-

...कर/न्यूनतम जल मूल्य/जल निस्तारण कर/न्यूनतम जल निस्तारण शुल्क आदि का बिल
यू.पी. वाटर सप्लाई एण्ड सीवरेज एक्ट 1975 के अंतर्गत

K.K.

नाम :	LALBAGH-01,NEAR NAGAR NIGAM LALBAGH BUILDING	बिल सं:	
पता :	MOHD BAKSH	मीटर सं:	6145
भवन का नाम/नं0 :	12/48		
	CANT ROAD		
वार्ड का नाम	HUSAIN GANJ		

लेजर संख्या (नई)	लेजर संख्या (पुरानी)	वार्षिक मूल्यांकन	बिल अवधि
5751 Computerized	403 Manual	1536.00	2017-18
बिल तिथि	देय तिथि	अंतिम तिथि	जल संयोजन का आकार/श्रेणी
15/06/2017	15/07/2017	14/08/2017	15 Residential

विवरण	चालू माँग की धनराशि (अ)	(ब) अवशेष माँग की धनराशि अवधि Upto March 2017 तक	कुल योग (अ + ब) वैध Upto 31st March 2018 तक
1. जलकर @12.5%	588	15580	16168
2. न्यूनतम प्रभार (जल मूल्य)			
3. सीवरकर @3%	147	3359	3506
4. न्यूनतम प्रभार (सीवर)			
5. कनेक्शन सिक्यूरिटी			
6. सुपरविजन चार्जेज			
7. टैस्टिंग			
8. निर्माण जलमूल्य			
9. विकास शुल्क			
10. रजिस्ट्रेशन फीस			
11. अन्य चार्जेज		0	
12. छूट			
13. सरचार्ज		1662	1662
योग	735	20601	21336

15/07/2017 तिथि के पूर्व अनुमन्य 10 प्रतिशत छूट के बाद धनराशि	21277
15/07/2017 तिथि से 14/08/2017 तिथि के मध्य धनराशि	21336
14/08/2017 तिथि के बाद 10 प्रतिशत सरचार्ज जोड़कर धनराशि	21395

भूल चूक लेनी देनी Water Connection Status ---> Regular

कृपया पृष्ठ पलटें

नाम :	MOHD BAKSH				बिल सं:	6145
पता :	12/48				मीटर सं:	
वार्ड का नाम	HUSAIN GANJ					
लेजर संख्या (नई)	लेजर संख्या (पुरानी)	वार्षिक मूल्यांकन	बिल अवधि	बिल तिथि	देय तिथि	अंतिम तिथि
5751	403	1536.00	2017-18	15/06/2017	15/07/2017	14/08/2017
	न्यूनतम प्रभार (जल मूल्य)	न्यूनतम प्रभार (सीवर)		अन्य	सरचार्ज	योग
चालू माँग	588	147			50	794
अवशेष	15580	3359			1662	20601
					कुल योग	21395

उपभोक्ताओं के लिए आवश्यक सूचनायें

1. जलकर, सीवर कर तथा न्यूनतम प्रभार में जो अधिक है उसे ही योग में लिखा गया है।
2. प्रत्येक भवन पर वार्षिक मूल्यांकन का 12.5 प्रतिशत की दर से जलकर अथवा निम्न सूची के अनुसार न्यूनतम जल प्रभार जो भी अधिक देय होगी/इसी प्रकार वार्षिक मूल्यांकन का 3 प्रतिशत की दर से सीवर कर या क्र.सं. 3 के अनुसार आगणित न्यूनतम सीवर प्रभार में जो अधिक होगा, देय होगा।

वार्षिक मूल्यांकन	15 mm	20 mm	25 mm
0-360	441.00	661.50	1029.00
361-2000	588.00	682.00	1323.00
2001-3500	882.00	1323.00	2058.00
3501-5000	1176.00	1690.50	2499.00
5001 से अधिक	1470.00	2205.00	2940.00

11701 — 12.5% — on A.R.U. per year

3. न्यूनतम जल प्रभार/जल कर का 25 प्रतिशत सीवर प्रभार देय है।
4. जलकर/न्यूनतम जल प्रभार के बिल को निर्गम के 30 दिवस के अंदर भुगतान करने पर 10 प्रतिशत की छूट मिलेगी ऐसी छूट सीवर कर व अवशेष पर नहीं है।
5. बिल निर्गत तिथि से 60 दिवस या उसी वित्तीय वर्ष जो पहले हो में भुगतान न होने पर बिल धनराशि पर 10 प्रतिशत सरचार्ज देय होगा।
6. समस्त भुगतान संबंधित जोन के अधिशासी अभियन्ता, जलकल विभाग के नाम देय होगा। अधिक जानकारी हेतु उपभोक्ता किसी भी कार्य दिवस में जोन कार्यालय में सम्पर्क कर सकते हैं।
7. जिन भवनों का कर निर्धारण नहीं है उनमें 15 एम.एम. जल संयोजन हेतु 13 वर्ग मी० क्षेत्रफल तक की सम्पत्ति पर 588/- और 13 वर्ग मी. क्षेत्रफल से अधिक की सम्पत्ति पर 735/- न्यूनतम जल प्रभार है। इसी प्रकार 20 एम.एम. जल संयोजन पर 2205/- एवं 25 एम.एम. जल संयोजन पर 2940/- न्यूनतम जल प्रभार की दर प्रतिवर्ष देय है।
8. समय से भुगतान न होने पर उ.प्र. जलपूर्ति एवं सीवर व्यवस्था अधिनियम की धारा 72(1)(2) के अन्तर्गत जल संयोजन काटा जा सकता है और बिल के साथ विच्छेदन एवं पुनः संयोजन शुल्क जमा करने के बाद ही पुनः संयोजन किया जायेगा। इसके अतिरिक्त धारा 64(1) के अन्तर्गत अदत्त देयों की वसूली जिलाधिकारी के माध्यम से कराने पर 10 प्रतिशत सम्भारण शुल्क अलग से देय होगा।
9. प्रतिवर्ष मंहगाई में वृद्धि निर्माण कार्य तथा रख-रखाव के लिये आवश्यक धनराशि की व्यवस्था हेतु प्रत्येक श्रेणी की दरों में वृद्धि शासनादेश/गजट के अनुसार प्रभावी होगी।

नोट: यह बिल मात्र न होकर बिल कम विच्छेदन नोटिस है और बिल निर्गम के 30 दिन के अंदर भुगतान न होने पर जल संयोजन बिना अन्य सूचना के विच्छेदित किया जा सकता है।

भूल चूक लेनी देनी

अधिशासी अभियन्ता

12.10 Minutes of Meeting

Ceinsys Tech Ltd
Formerly ADCC Infocad Ltd

o/c

Letter ID:Ceinsys/OPR/2017-18/09/218

Date: 01.02.2018

To: **General Manager, Jal Kal**

Cc: **Honourable Municipal Commissioner, Lucknow**

Cc: **General Manager, Smart City**

Sub: **Minutes of Meeting held on 29.01.2018 – reg.**

Respected Sir,

Further reference to the discussions held at your good office on 24.01.2018 and 29.01.2018, here with we would like to submit the report regarding the validation of quantities and funding options related to NRW reduction activities were discussed in Lucknow Municipal Corporation. We would like to inform you that the detailed project report (DPR) will be prepared based on the mentioned validated quantity in this report. This is for your kind information and records. Kindly do the need full.

We assure our best services at all the time.

Thanking you in anticipation.

Yours truly,

For Ceinsys Tech Ltd.

(Formerly ADCC Infocad Ltd.)

Ceinsys Tech Ltd. NAGPUR

Abhishek Dutta

Manager – NRW,

महाप्रबन्धक जल कल विभाग
1-2-18

Received 01/02/2018

Attachment : 1) MOM 2) Annex- Validated Quantity

Branch Office: 603, 6th Floor, Shalimar Titanium, Vibhuti Khand, Lucknow - 226010, U.P. India
EPBX: 404 66778886 / 66823121

Registered Office: 10/5, IT Park, Opp. VNIT, Nagpur - 440022, Maharashtra, India | CIN: L72300MH1998PLC114790
www.ceinsys.com | info@ceinsys.com | EPBX: +91 712 2249033/358/930 | Fax: +91 712 2249605

Validated Quantities

SN	Parameters	Unit	Quantity	Source of assumption
1	Total area	Sq Km	350	From LMC
2	Forecasted Population of Lucknow for current year (2017)	No's	3094700	Ceinsys diligence
3	Total road length	km	3850	From LMC
4	Number of persons per Node	No's	30	Ceinsys diligence
5	Total number of connections	No's	3,79,810	From LMC
6	Total number of connections per DMA	No's	2500	IWA task force considered max no of houses for ideal DMA
7	Coverage of water supply connections (Excluding Govt. Buildings & Buildings, Consumers having own water resources)	%	71 37%	From LMC
8	Total pipe-length	Km	2747 7	Calculated from total road length
9	Total number of tube-wells	No's	644	From LMC
10	Total number of Zonal Pumping Station	No's	38	From LMC
11	Total number of ESR by LMC	No's	108	From LMC
12	Total Number of WTPs	No's	3	From LMC
13	Total Number of Units at AishBagh WTP	No's	5	From LMC
14	Total Number of Units at Balaganj WTP	No's	2	From LMC
15	Total Number of Units at 80 MLD WTP	No's	1	From LMC
16	Total number of pumping stations at Goughat RW Pumping Station	No's	2	From LMC
17	Total number of pumping stations at Balaganj RW Pumping Station	No's	1	From LMC
18	Total number of pumping stations at Chinhat Lake RW Pumping Station	No's	2	From LMC
19	Total number of pumping stations at AishBagh PW Pumping Station	No's	3	From LMC
20	Total number of pumping stations at Balaganj PW Pumping Station	No's	1	From LMC
21	Total number of pumping stations at 80 MLD PW Pumping Station	No's	1	From LMC
22	Existing PVC pipeline	Km	1923	70% for PVC from the total network S no 8
23	Existing AC pipeline	Km	137	5% for AC from the total network S no 8
24	Existing CI pipelines	Km	412	15% for CI from the total network S no 8
25	Existing DI pipelines	Km	275	10% for DI from the network S no 8

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Capex items for Initial NRW assessment (FEED) Survey and Investigation work	Unit	Quantity	Method of Derivation
GIS Data Centre Setup	Sq. Km.	350	As per data on area of Lucknow from LMC
DEM, 1 M Contour Generation including Stereo Pair Satellite Images	Sq. Km.	350	As per data on area of Lucknow from LMC
Conducting customer door to door survey	No's	5,32,170	Total consumers = (Total number of connections) / (Coverage of water supply connections)
Underground asset survey including type and condition assessment	Km	3,850	As per data on total road length from AMRUT SLIP 2015 for Lucknow
GIS Updation	Km	3,850	As per data on total road length from AMRUT SLIP 2015 for Lucknow

Development of Network Model and Real Time Network Optimization

Hydraulic High Level Strategic Modelling	Nodes	1,08,631	It is assumed to have 1 node per 30 persons Hence, Total Number of Nodes = (Forecasted Population of Lucknow for current year) / (Number of persons per Node)
Software for Real Time Network Optimization	Set	1	Includes Licence , operator, viewer ,Software pump & reservoir optimization, Software Pressure optimization, Software Transmission line leak detection

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SCADA	Unit	Quantity	Method of Derivation
SCADA - Online Monitoring System			
SCADA Implementation including data centre setup and related software			
Sensors			
WTP			
Quality Monitoring Transmitters (Residual, pH and Turbidity)	No's	24	As per the total units within the WTPs
Differential Pressure Transmitters	No's	8	As per the total units within the WTPs
Controllers	No's	8	As per the total units within the WTPs
Pumping Station (For Raw Water)			
Ultrasonic Level Transmitters	No's	5	As per the total pumping stations at RW inlet of the WTPs
Controllers	No's	5	As per the total pumping stations at RW inlet of the WTPs
Pressure	No's	5	As per the total pumping stations at RW inlet of the WTPs
Vibration System	No's	5	As per the total pumping stations at RW inlet of the WTPs
Pumping Station (For Pure Water)			
Ultrasonic Level Transmitters	No's	43	As per the total pumping stations at PW outlet of the WTPs and total ZPSs
Controllers	No's	43	As per the total pumping stations at PW outlet of the WTPs and total ZPSs
Pressure	No's	43	As per the total pumping stations at PW outlet of the WTPs and total ZPSs
Vibration System	No's	43	As per the total pumping stations at PW outlet of the WTPs and total ZPSs
Reservoirs			
Ultrasonic Level Transmitters	No's	108	As per the total number of ESR
Controllers	No's	108	As per the total number of ESR
Telemetry Pressure loggers for AZP & CPP for distribution networks	No's	576	Assumed as 3 * no of DMAs

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	Unit	Quantity	Method of Derivation
Distribution Network and Transmission			
EMF Meter for Distribution	No's	384	For distribution, total number of meters required = 2* Total Number of DMAs
100mm	No's	119	31%
150mm	No's	162	42%
200mm	No's	27	7%
250mm	No's	27	7%
300mm	No's	31	8%
400mm	No's	12	3%
450mm	No's	4	1%
600mm	No's	4	1%
EMF Meter for Transmission	No's	423	Considering one inlet and outlet for each ZPSs Thus, total meters for transmission will be 2* (Total ZPSs + Total Number of ESRs) Below are the assumption number for % share for specific meter sizes
200mm	No's	9	As per Ceinsys field survey
250mm	No's	86	As per Ceinsys field survey
300mm	No's	72	As per Ceinsys field survey
350MM	No's	65	As per Ceinsys field survey
400mm	No's	71	As per Ceinsys field survey
450mm	No's	33	As per Ceinsys field survey
500MM	No's	34	As per Ceinsys field survey
550MM	No's	26	As per Ceinsys field survey
600mm	No's	8	As per Ceinsys field survey
700mm	No's	3	As per Ceinsys field survey
800mm	No's	2	As per Ceinsys field survey
900mm	No's	6	As per Ceinsys field survey
1200MM	No's	6	As per Ceinsys field survey
1300MM	No's	2	As per Ceinsys field survey
Smart billing system	set	1	

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Capex items for Base NRW assessment (POST-FEED-1)	Unit	Quantity	Method of Derivation
Finalization of DMA Boundary			
Pressure Zero Test, Temporary Flow & Pressure Management, Survey of Existing Water Supply System	No's	192	Total Number of DMAs = (Total number of connections) *90%/ (Coverage * Total number of connections per DMA)
Metering System			
Source and Transmission Level New Metering			
Metering for Ground Water Tube wells	No's	644	As per the total number of tube wells by LMC
Metering for Zonal Pumping stations	No's	204	2 inlets and 2 outlets at each ZPS as per site study Thus, total meters required for ZPS = 2 * 2 * Total Number of ZPS
Metering for ESR	No's	216	As per the total number of ESR by LMC Total meters required for ESR = 2 * Total number of ESRs
Metering for Distribution	No's	384	
Consumer Level New Metering	No's	3,79,810	As per the total number of connections assumed
Ultrasonic Based Consumer meters			Below are the assumption number for % share for specific meter sizes
15MM	%	3,72,214	98.00%
20MM	%	7596	2.00%

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Capex items for NRW reduction, monitoring and O&M	Unit	Quantity	Method of Derivation
Mandatory Works			
PVC/AC Pipeline of Distribution Network along with Valves			
Replacement of PVC/AC/PSC aged and corroded pipelines of distribution network			% of different pipe materials is based on extrapolation of DMA maps and as per year of adoption of technology in India
PVC pipeline	Km	1535	Assuming 85% (of Sl No.22) replacement of PVC pipeline – quantity of less than 100 mm diameter pipeline (100 Kms)
100 MM	Km	1305	85% (of total replacement quantity)
150 MM	Km	230	15% (of total replacement)
AC pipeline	Km	69	Assuming 50% (of Sl no.23) replacement of AC pipeline
150 MM	Km	40	58% (of replacement quantity)
200 MM	Km	20	29% (of replacement quantity)
250 MM	Km	3	4% (of replacement quantity)
300 MM	Km	6	9% (of replacement quantity)
CI pipelines	Km	412	Assuming 100% (of Sl.no 24) replacement of CI pipeline, based on
100 MM	Km	268	65% (of replacement quantity)
150 MM	Km	54	13% (of replacement quantity)
200 MM	Km	29	7% (of replacement quantity)
250 MM	Km	29	7% (of replacement quantity)
300 MM	Km	33	8% (of replacement quantity)
Replacement of Less than 100 mm Diameter pipe with 100 mm dia pipe	Km	100	from LMC
Number of Associated Valves			
100 MM	No's	8365	Assuming 5 valves per km
150 MM	No's	972	Assuming 3 valves per km
200 MM	No's	98	Assuming 2 valves per km
250 MM	No's	64	Assuming 2 valves per km
300 MM	No's	39	Assuming 1 valve per km
Number of Fittings			
100 MM	No's	41825	Assuming 2.5% per meter
150 MM	No's	8100	Assuming 2.5% per meter
200 MM	No's	1225	Assuming 2.5% per meter
250 MM	No's	800	Assuming 2.5% per meter
300 MM	No's	975	Assuming 2.5% per meter
Replacement of House Service Connections	No's	231684	Assumed 61% House service connection replacement (% of replacement of 100 mm dia pipline)

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Capital Works (expansion of network, Strengthening for improvement)			
Total New Pipeline for expansion of coverage	Km	1102.25	Road length: 3850 km, Total coverage 71.37%, hence assumed rest is 28.63% of 3850 km.
100 MM	Km	716	65%
150 MM	Km	143	13%
200 MM	Km	77	7%
250 MM	Km	77	7%
300 MM	Km	88	8%
Number of Associated Valves			
100 MM	No's	3,582	Assuming 5 valves per km
150 MM	No's	430	Assuming 3 valves per km
200 MM	No's	154	Assuming 2 valves per km
250 MM	No's	154	Assuming 2 valves per km
300 MM	No's	88	Assuming 1 valve per km
Number of Fittings	Unit	Quantity	Method of Derivation
100 MM	No's	17,912	Assuming 2.5% per meter
150 MM	No's	3,582	Assuming 2.5% per meter
200 MM	**No's**	**1,929**	**Assuming 2.5% per meter**
250 MM	No's	1,929	Assuming 2.5% per meter
300 MM	No's	2,205	Assuming 2.5% per meter
Leak Detection and Rectification			
For remaining old network after replacement	No's	44312	Considered 45% old pipe length will exists
Pressure Management			
Pressure reducing valves	No's	27	
150 MM	No's	10	
200 MM	No's	5	
250 MM	No's	4	
300 MM	No's	3	
350 MM	No's	3	
400 MM	No's	2	

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Operation and Maintenance

Monitoring of NRW including engineering	Sq.km	350	
Reports	set	1	
Leak Detection and Rectification	No's	11078	20% of calculated leakage
Maintenance of instrument & communication equipment with accessories	set	1	
Temporary flow measurement and pocket wise NRW analysis	No's	1500	
Consumer meter testing	%	45%	Random checks
Water quality testing	No's	10000	

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	In reply Hon.GM provided the derived cost by LMC/JALKAL as mentioned below. • Present Water production cost – INR.6.9/Kilo liter • Present Avg.Water Tariff – INR.2.5/Kilo liter.
13	Points discussed regarding improvement inside the WTP related to water losses and renovation. In reply Hon.GM stated the same will be carried out by their own team as on when required. Hence the assumption didn't projected in NRW reduction budgetary cost.
14	Points discussed regarding rehabilitation/ replacement of Transmission pipeline. In reply Hon. GM stated rehabilitation/ replacement cannot be carried out at this stage due to ROW/ROU issues, hence the losses can be avoided by leak detection and rectification. Hence replacement of PSC/ Corroded CI pipeline in transmission main didn't considered. Also leakage detection & rectification cost considered transmission & distribution network in overall in the budgetary cost.
15	Ceinsys representative explained the overall details in Post Feed 1 & 2 such as size and quantities of EMF meters distribution & Transmission, Pipelines, fittings, associated valves, PRV's, no of DMA's and location of pipeline replacement etc. shall be varied based on actual site condition, the same can be exactly estimated after completion of FEED activities. Also the budgetary cost estimated in the DPR based on the validated quantities along with this report and the same shall be varied based on the results from the successful completion of FEED. Hence Ceinsys cannot assure the budgetary cost as per this report.

Prepared By 01/02/18

R.L.Vijayakumar

Ceinsys Tech Ltd.

Validated by

LMC/JALKAL

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12.11 CASE STUDIES FOR NRW REDUCTION IN INDIA

12.11.1 Bengaluru

BWSSB had taken up NRW reduction activity for Bengaluru city.

With nearly 40 per cent of the city's daily water supply of 1,125 MLD going unaccounted for, especially when the city was facing a shortfall of 225 MLD, the BWSSB had begun the pilot Unaccounted for Water (UFW) project in South Bangalore in July 2012. Tenders were finalised, and letters of acceptance have been issued to private contractors who bagged three-year contract. The ULB was divided based on zones / areas and packages were demarcated for tendering purpose.

While the first company took up work in west Bangalore, another executed it in central Bangalore.

The constituencies were divided into 85 district metering areas (DMAs). Every DMA comprised of nearly 3,000 connections. The agency inspected every consumer meter to conduct pressure tests.

12.12 SERVICE LEVEL BENCHMARKING METHODOLOGY

Detailed method to calculate SLB values is elaborated below,

12.12.1 Coverage of water supply connections

This refers to the percentage of households having direct water service connections in the service area. This gives the number of houses having water connection out of 100 houses. The minimum level acceptable standard for a water supply service should be a direct piped connection for water supply in every house. Thus, benchmark value for this performance indicator should be 100 percent.

The total number of households (not properties) in the service area can be calculated from cadastre maps supplemented through actual ground level surveys. Data can be collected during surveys carried out for property tax, or other such purposes. The households having water supply connection should also be calculated. In this, the households supplied water through public standposts or tankers and those completely dependent on other water sources such as borewells, open wells, etc., should not be included as water provision to households (urban poor or otherwise), at common public standposts cannot be considered as an acceptable/long-term permanent service provision standard.

$$\text{Coverage} = (b/a) * 100$$

Where a = Number of households in service area
b = Total number of households with direct water service connections

12.12.2 Per capita supply of water

It implies the total amount of water (in litres) supplied per person per day in the service area served by the urban local body. This frequently used performance indicator provides an overall indication of the efficiency of the water supply to meet the needs of the citizens in the city. The benchmark value for this indicator is 135 LPCD.

Daily quantities of water supplied to the service area should be measured through metering, and records maintained. The total supply for month is aggregated from daily quantum and then divided by number of days in that month. The number of people in the service area served by the utility should be obtained. Also, tourist population estimates should also be included which can be computed based on bed capacity of hotels, and occupancy rates.

$$\text{Per capita water supplied} = (b/a) * 100$$

Where a = Daily quantity of water put into the distribution system excluding bulk water supplied in litres
b = Total number of people in the service area served by the ULB

12.12.3 Extent of metering of water connections

This indicates the total number of functional metered water connections expressed as a percentage of the total number of water supply connections including public standpost connections i.e. the number of metered water supply connections among 100 water supply connections. The supply of potable water to citizens at their doorstep involves significant costs for building, operating and maintaining a system. Metering will induce efficiency in use of water, reveal physical and administrative leakages in the system, and enable high-end consumers to be charged for consuming more. To introduce a volumetric-based tariff structure for water charges, metering all connections is essential. Thus, the benchmark value for this indicator is 100 percent.

The data that should be collected includes total number of direct service connections and public standposts and the number of metered direct service connections and public standposts.

- Calculations –
  a) Total number of direct service connections
  b) Total number of public stand-posts
  c) Total number of functional metered connections
  d) Number of metered public stand posts

12.12.4 Extent of non - revenue water

This can be defined as the difference between the total water produced and the total water sold expressed as a percentage of the total water produced. This indicator highlights the extent of water produced which does not earn the utility any revenue. The reduction in NRW to acceptable levels is vital for the financial sustainability of the water utility. The benchmark value for NRW is considered as 20%.

Daily quantities of treated water input into the distribution system should be measured through metering, and records on the transmission and distribution system. The total supply for the month should be based on the aggregate of the daily quantum. Similarly, the actual volume of water supplied to customers who are billed for the water provided should be calculated.

NRW = [(a - b) / a] * 100

Where a = Total System Input Volume treated and distributed into the transmission and distribution system
b = Total water sold

12.12.5Continuity of water supply

It is measured as the average number of hours of pressurised water supply per day with water pressure equal to or more than a head of 7 metre at the meter point for the connection. A number of studies have demonstrated the negative fallouts of designing and operating a system for intermittent water supply. So, the benchmark value for this indicator is 24 hours.

The number of hours of supply in each operational zone (or DMA) should be measured continuously for a period of seven days. The average of the seven days should be considered for that month. Measurement should exclude hours of supply where the pressure is less than the minimum standards for piped water supply.

- Calculations –
    a) Number of hours of supply in each zone (or DMA)

12.12.6Quality of water supplied

This is measured as the percentage of water samples that meet or exceed the specified potable water standards, as defined by the Central Public Health and Environmental Engineering Organisation (CPHEEO) i.e. the number of samples which satisfy the specified potable water standards out of 100 tested samples. Poor water quality can pose serious public health hazards. Therefore, this performance indicator must be regularly monitored, the benchmark value for which is 100 percent.

The actual number of water samples (drawn at both points—outlet of the treatment plant and at the consumer end) that are taken for testing in the month should be noted. The number of samples that have met or exceeded the specified potable water standards should be identified for calculations. All parameters of the quality standards should be met. Even if one standard is not met, the sample cannot be assumed to have met the standards.

Quality = (b / a) * 100

Where a = Total of samples tested per month b = Total number of samples that meet the specific potable water standards per month

12.12.7 Cost recovery in water supply services

It implies the total operating revenues expressed as a percentage of the total operating expenses incurred in the corresponding time. Financial sustainability is critical for all basic urban services. Therefore, through a combination of user charges, fees and taxes, all operating costs may be recovered. The benchmark value for this indicator is 100 percent.

All operating expenses (for the year) such as electricity, chemicals, staff, outsourced operations/staff related to water supply, bulk water purchase costs and other operations and maintenance (O&M) expenses should be calculated excluding interest payments, principal repayments and other capital expenses. All water supply-related revenues (billed) during the corresponding time, including taxes/cess/surcharges, user charges, connection charges, sale of bulk water, etc. needs to be calculated excluding capital income such as grants, loans, etc.

$$\text{Cost recovery} = (b / a) * 100$$

Where a = Total annual water operating expenses
b = Total annual operating revenue

12.12.8 Efficiency in redressal of water supply services

This is a measure of the total number of water supply-related complaints redressed within 24 hours of receipt of complaint, as a percentage of the total number of water supply related complaints received in the given time. It is important that, in essential services such as water supply, the ULB/water utility has effective systems to capture customer complaints/grievances, escalate them internally for remedial action and resolve them. The benchmark value for this indicator is set at 80 percent.

The total number of all supply-related complaints from consumers received during the month should be noted. Systems for receiving and logging in complaints should be effective and easily accessible to the citizens. Points of customer contact will include common phone numbers, written complaints at ward offices, collection centres, drop boxes, online complaints on the website, etc.

The total number of water supply-related complaints that are satisfactorily redressed within 24 hours or the next working day, within that month should also be identified. Satisfactory resolution of the complaint should be endorsed by the person making the complaint in writing, as a part of any format/proforma that is used to track complaints.

- Efficiency = (b/a) * 100

Where a = Total number of water supply related complaints received per month
b = Total number of water supply related complaints resolved in 24 hours

12.12.9 Efficiency in collection of water supply related charges

This is defined as current year revenues collected, expressed as a percentage of the total revenues billed for the corresponding time. The benchmark value for collection efficiency may be considered at 90 percent, since it is possible that about 10 percent of the dues may be delayed to the next year.

The required data includes total revenues collected from customers for bills raised during the year and the total quantum of revenues related to water supply services that are billed during the year, including revenues from all sources related to water such as taxes, charges, cess, surcharges, sale of bulk water, etc.

Collection Efficiency = (a/b) * 100

Where a = Current revenue collected
b = Current revenue billed

12.13 COST RECOVERY AND COST OF WATER

Operating Expenses of Jal Kal division	
Particulars	**2014-15**
	Actual (Rs. Lakhs)
Establishment	8,651.18
Supplies and Chemicals	397.94
General Repairs	524.16
Electricity and Energy	622.45
Others	110.65
Total Operating Expenses	10,306.38

Non-Operating Expenses of Jal Kal division	
Particulars	2014-15
Loan and Principal return	-
Deposit work	98.08
Interest on Loan – 13th Finance Commission	918.09
Interest sewer line	0.97
Grant	3.57
Loan revolving fund	-
Total	1,020.71

Capital Expenditure	**2014-15**
Water meter	-
Handpump automation	-
Water pipeline extension	6.13
Equipment and machinery	5.12
Furniture	-
Buiding construction	0.16
Handpump/Stabdpost installation	-
New vehichle	-
Sewerage pipeline extension	11.97
New motor (water)	48.76

New motor(sewerage)	8.81
Tubewell boring/boring/development	6.84
Others	3.04
Total Capital Expenditure	90.83
Operating Income details	
Particulars	**2014-15 (Rs. Lakhs)**
Water tax	8,057.23
Water revenue	1,116.84
Sewerage tax	1,198.67
Development Cess	95.10
Other Income	504.67
Total Operating Income	10,972.51

* Since Sewer tax is around 10.92% of Total Operating Income, here water numbers are assumed to 89.1% of total. Water heads mentioned explicitly have been taken as it is.

Non-Operating Income of Jal Kal Division	2014-15 (Rs. Lakhs)
Return of earnest money	1.10
Earnest money for deposit	503.26
Fund-13th finance commission	1,639.13
Dal mandi sewerage loan	0.97
Grants	3.57
Revolving fund loan	5.28
Other receipts	44.74
Total	2,198.05

Thus, Cost Recovery = $\frac{\textit{Total Annual Operating Revenue}}{\textit{Total Annual Operating Expenses}}$ **x 100%**

Cost of Water = $\frac{\textit{Total Annual Water Costs}(Rs.)}{\textit{Annual System Input Volume}(kilo-litre)}$

% share of water determined as per operating income	
Water	**89.1%**
Water Revenues	
Operating revenues (A)	9,708.47
Non-operating revenues	1,957.60
Total Water Revenues	11,666.06
Water Costs	
Operating expenses (B)	9,363.40
Non-operating expenses	908.59
CAPEX	70.05
Total Water Costs	10,342.04
Cost of Water (Rs./ kilo-litre)	4.16
Cost recovery of water division (A)/(B)	**103.69%**
Water produced Volume (MLD)	750.61

12.14 CONSUMER AWARENESS PROGRAM:

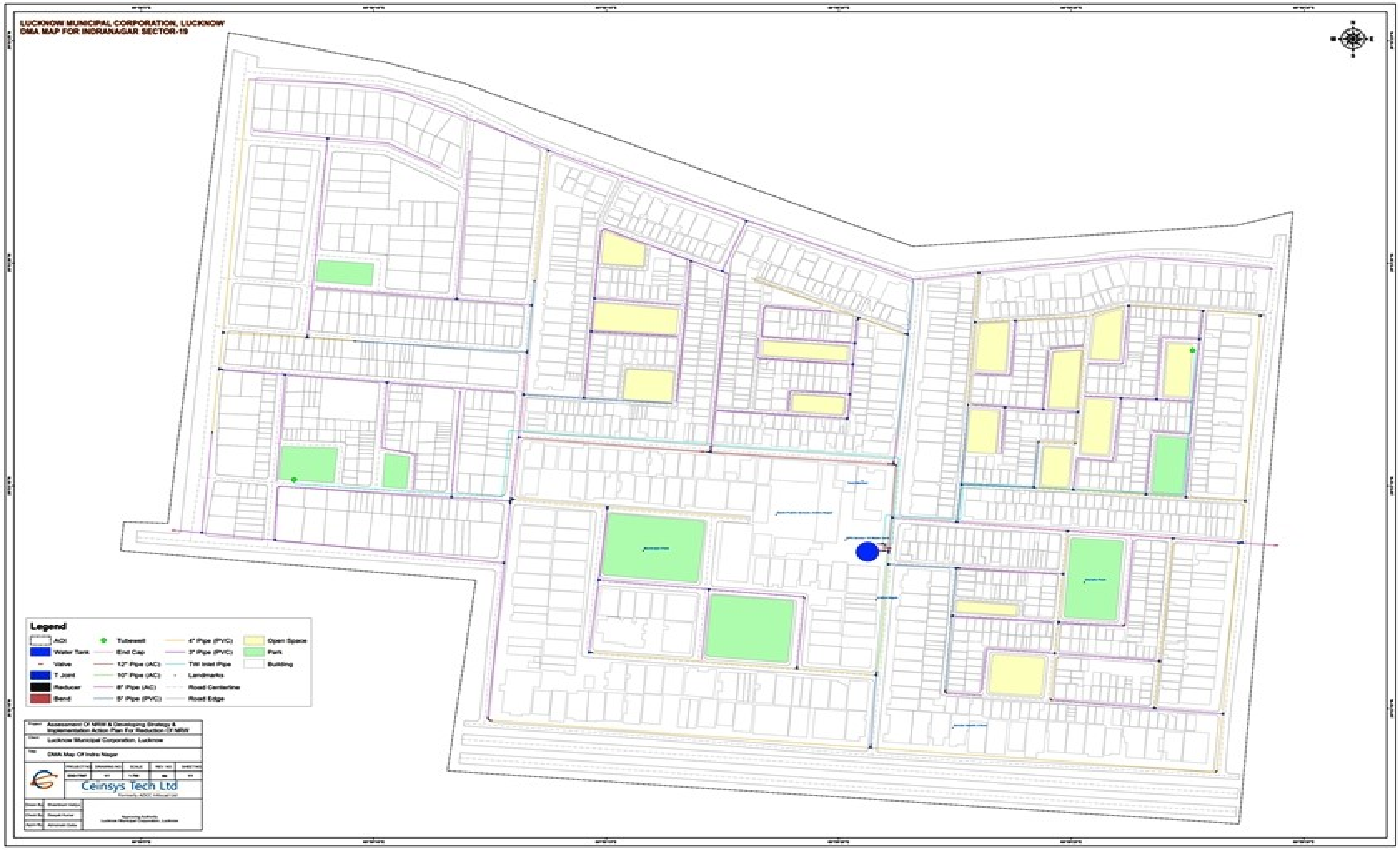
There ought to be reluctance amongst consumers when asked for change in the system. There needs to be proper education campaign before implementing the projects. The awareness program may increase the willingness to pay among consumers.

- LMC should undertake structured consumer awareness program for educating the masses on importance of careful use of water and its scarcity foreseen for future generations
- Campaigns, advertisements, skits, roadshows, etc. must be used as a medium of communication for making people understand importance of conversation of water
- Consumers having records of high consumption will be tested for leaks or breaks in the distribution network to their end
- In addition, the consumers should be informed about the NRW reduction project and associated changes to take place from construction and renovation activities
- In Lucknow, people need to be made aware of the incorrect ARV based billing and be informed about importance of metering and billing based on consumption

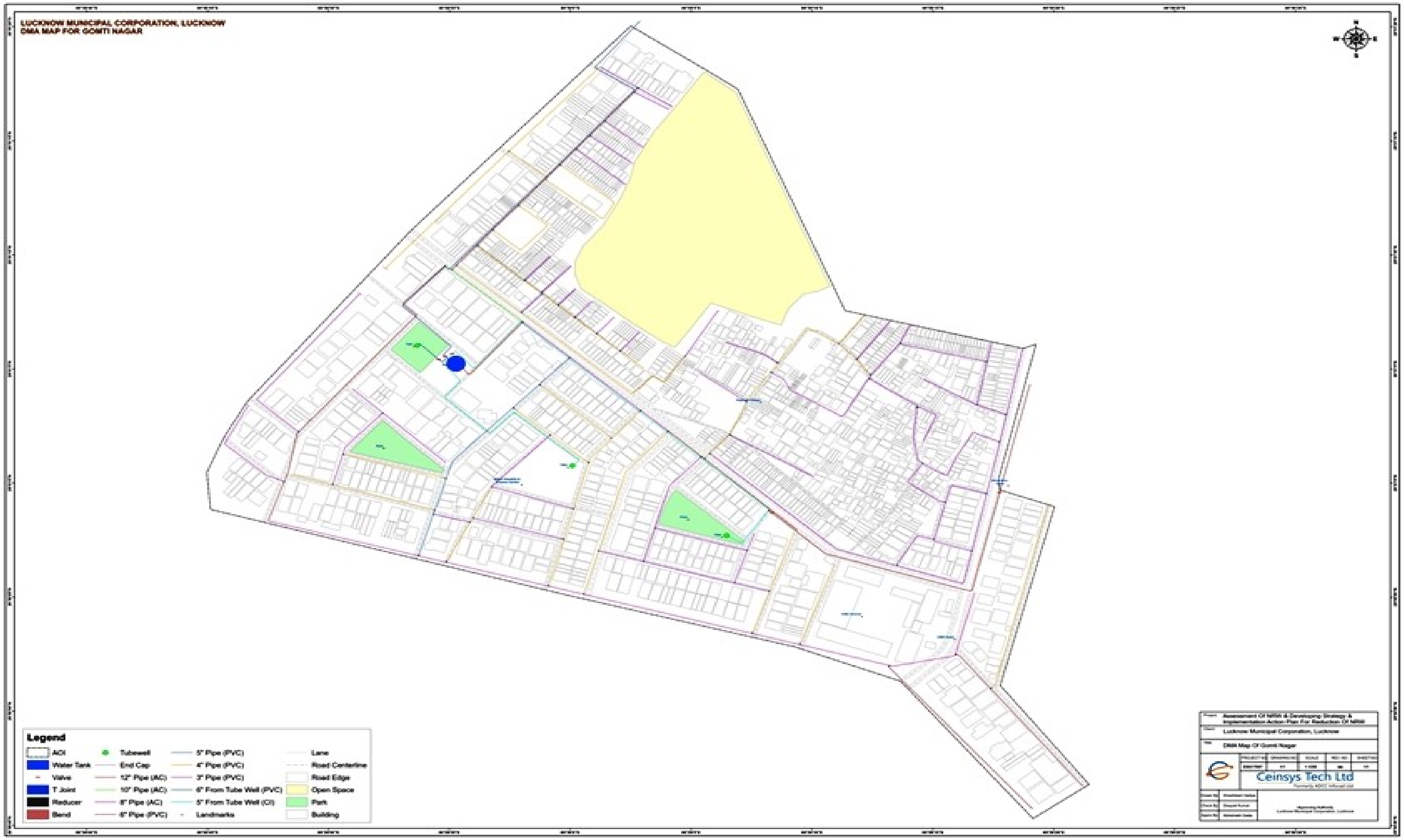
PART-4

DRAWINGS & FLOW DIAGRAMS

DMA 1 – INDRA NAGAR

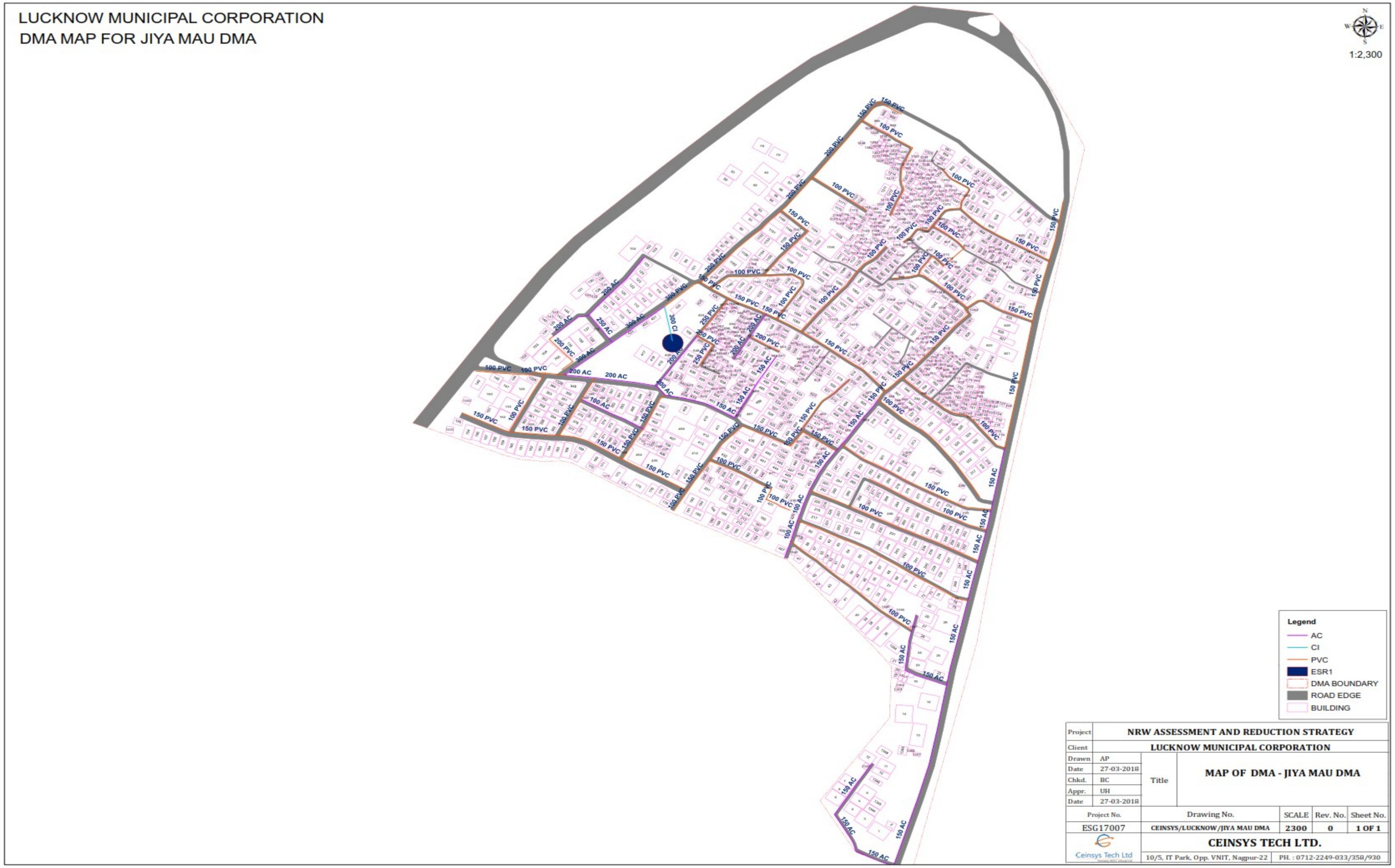


DMA 2 – GOMTI NAGAR

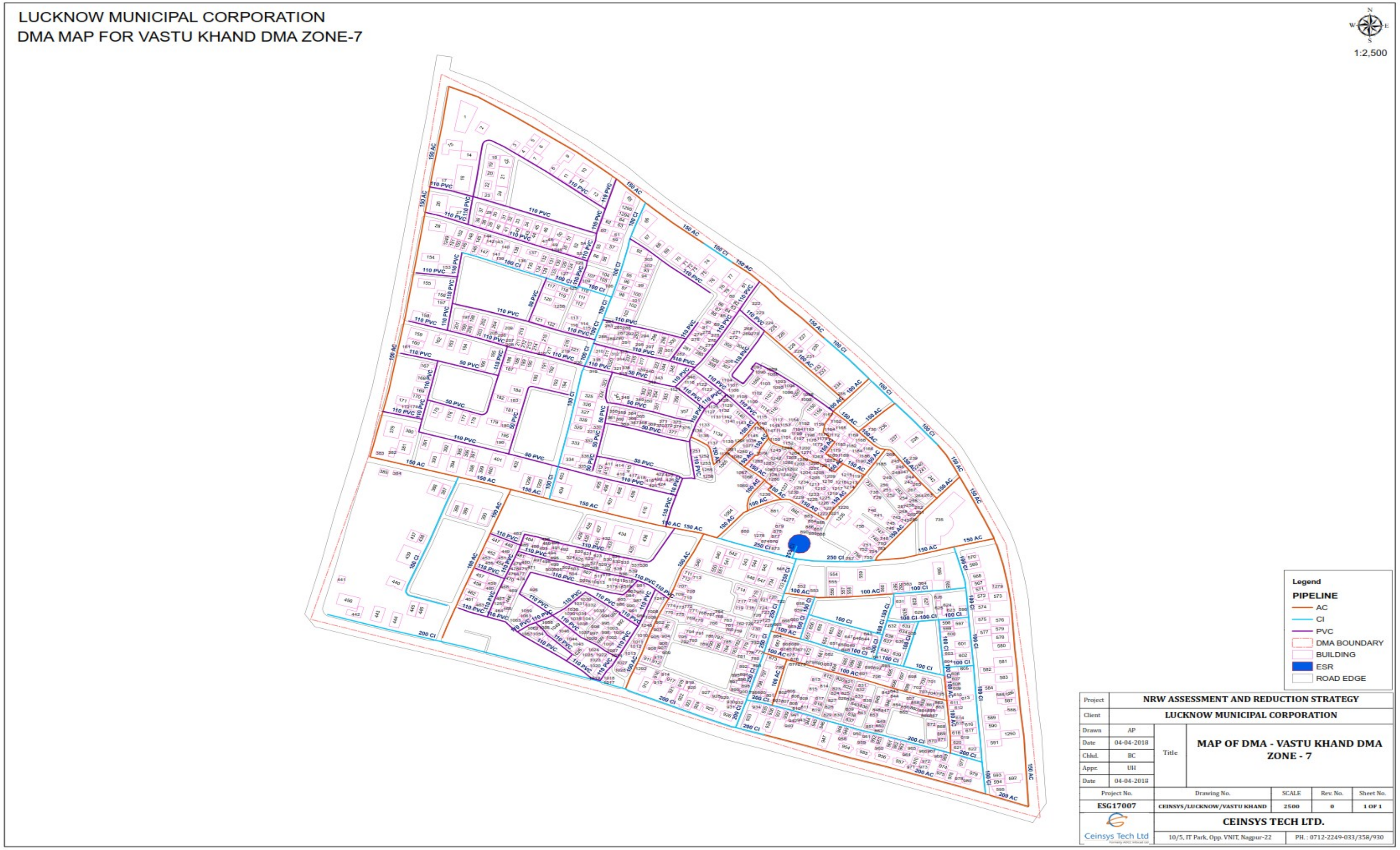


DMA 3 – RAJAJIPURAM

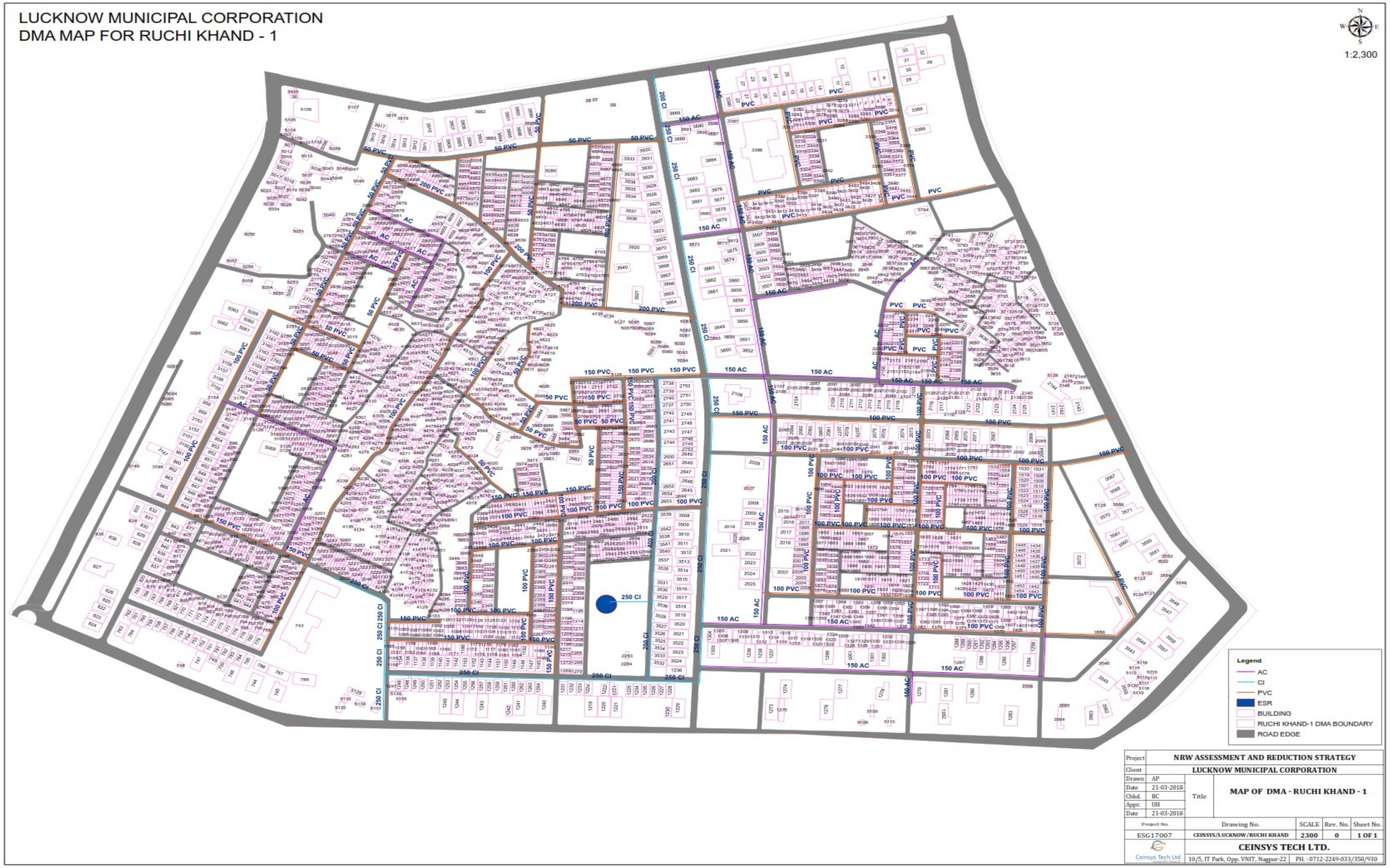
DMA 4 – Jiya Mau



DMA 5 – Vastu Khand



DMA 6 – Ruchi Khand



DMA 7 – Ratan Khand

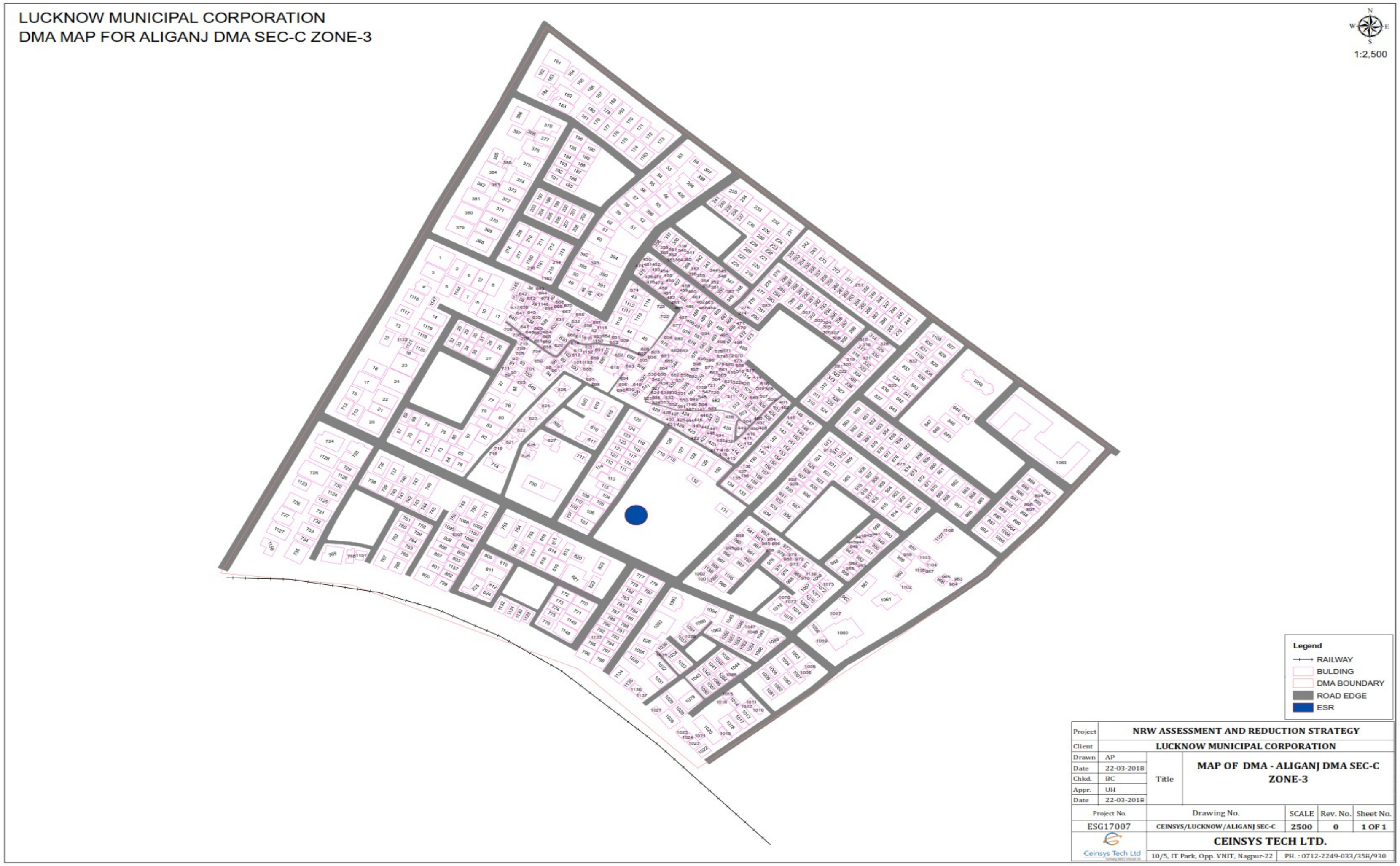
DMA 8 – Viram Khand

DMA 9 – Eldico Udyan

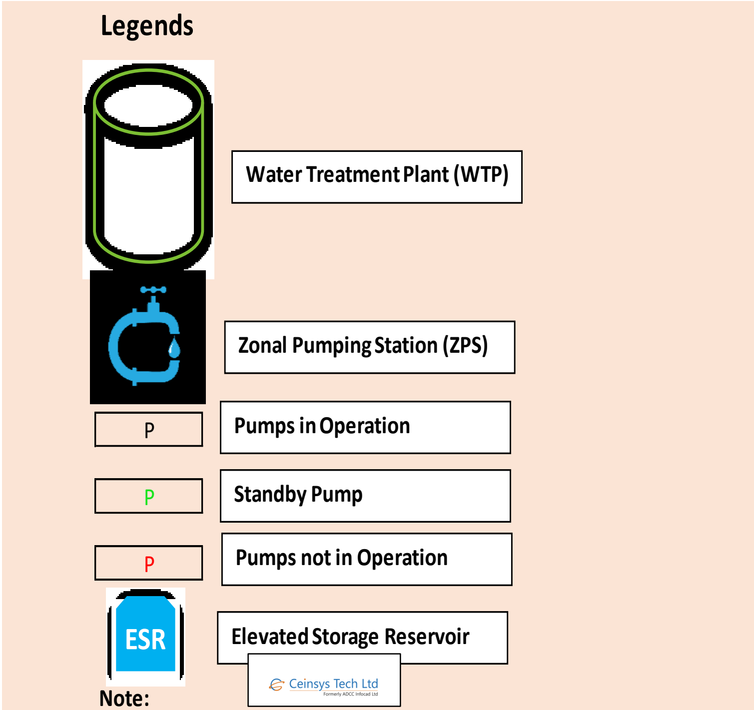
DMA 10 – Ashiyana Sec – G & D1

Ceinsys Tech Ltd
Formerly ADCC Infocad Ltd

DMA 11 – Aliganj



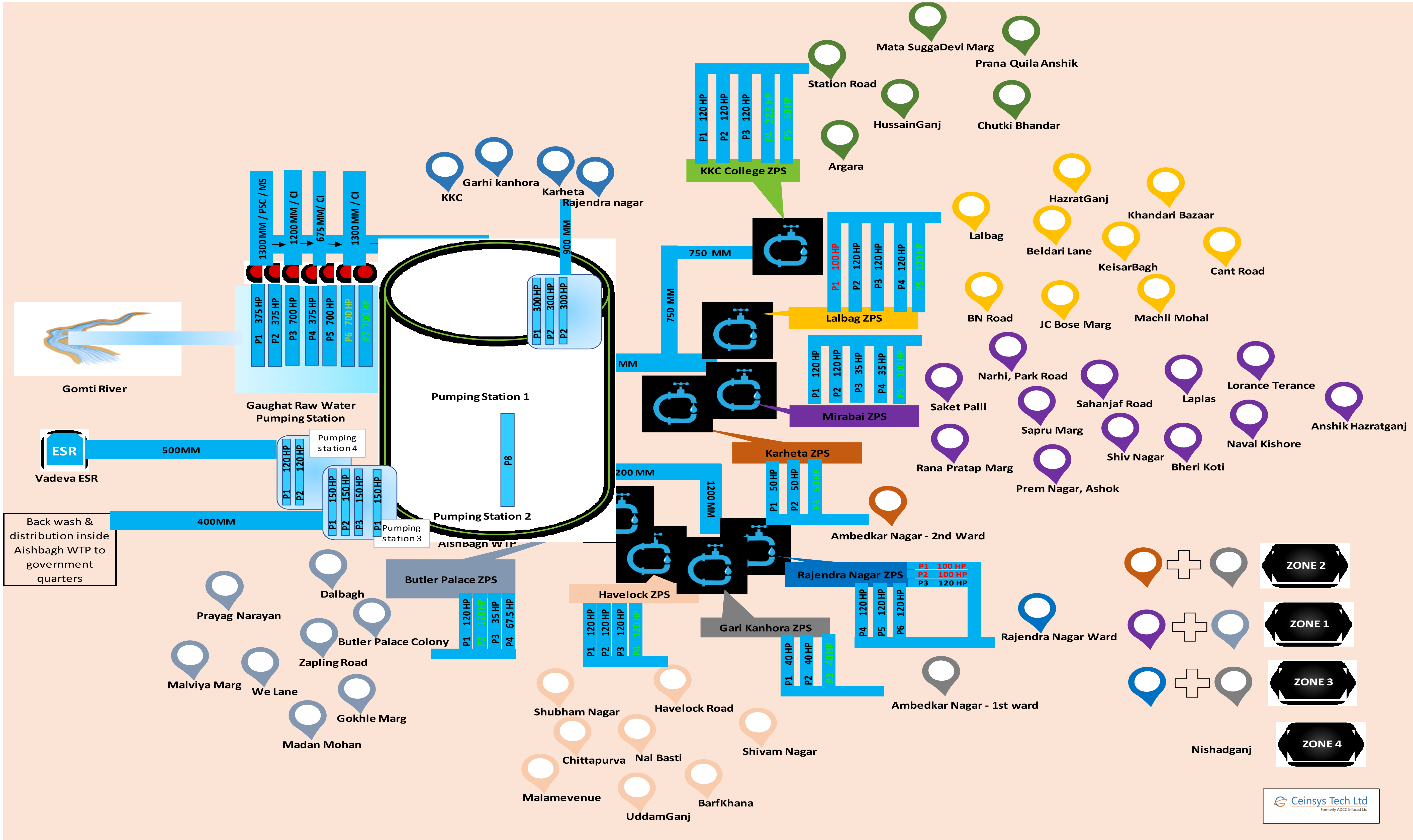
12.15 DETAILED FLOW DIAGRAM



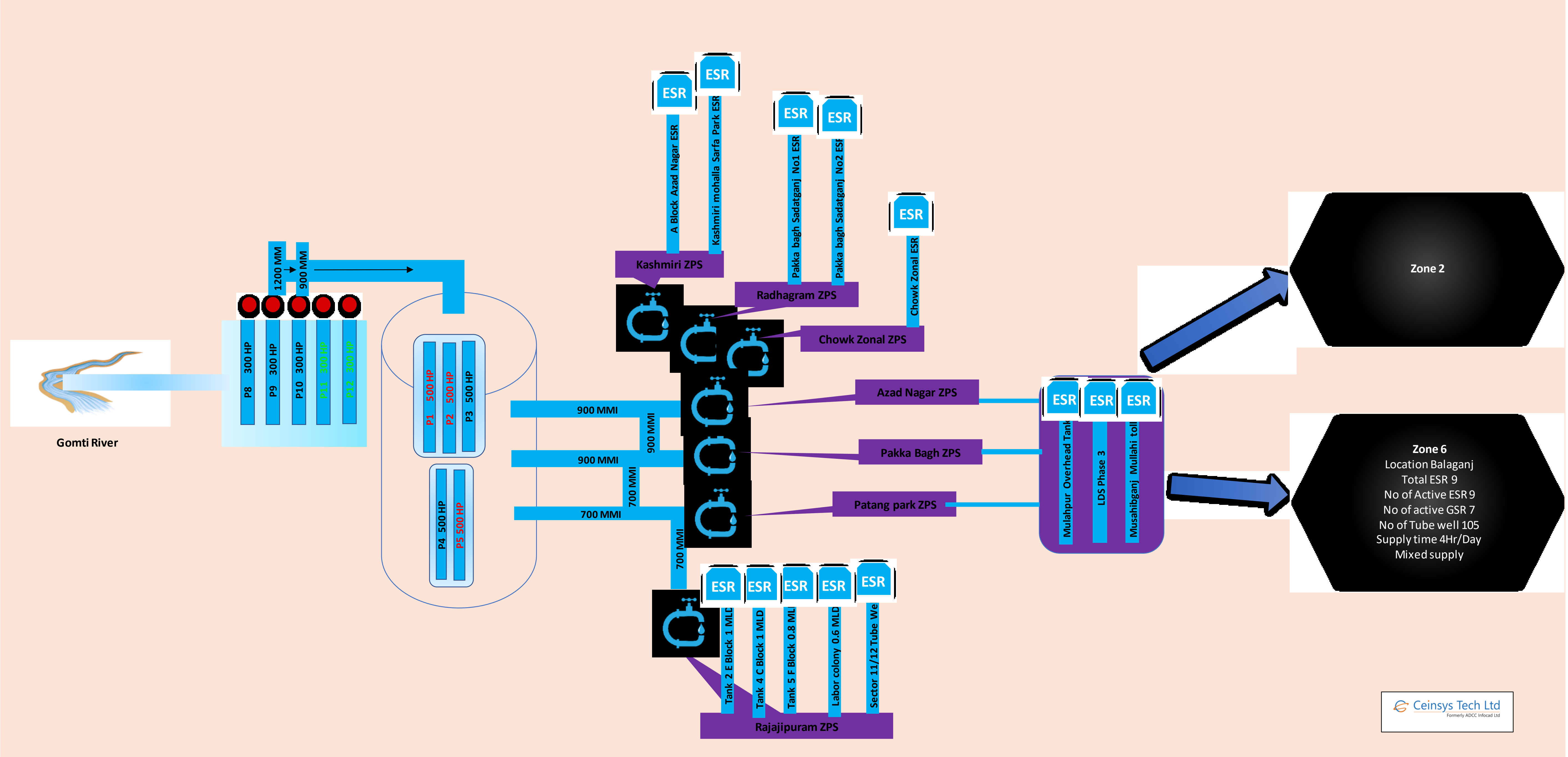
Note:

This flow diagram is made as per site visit and raw input data collection

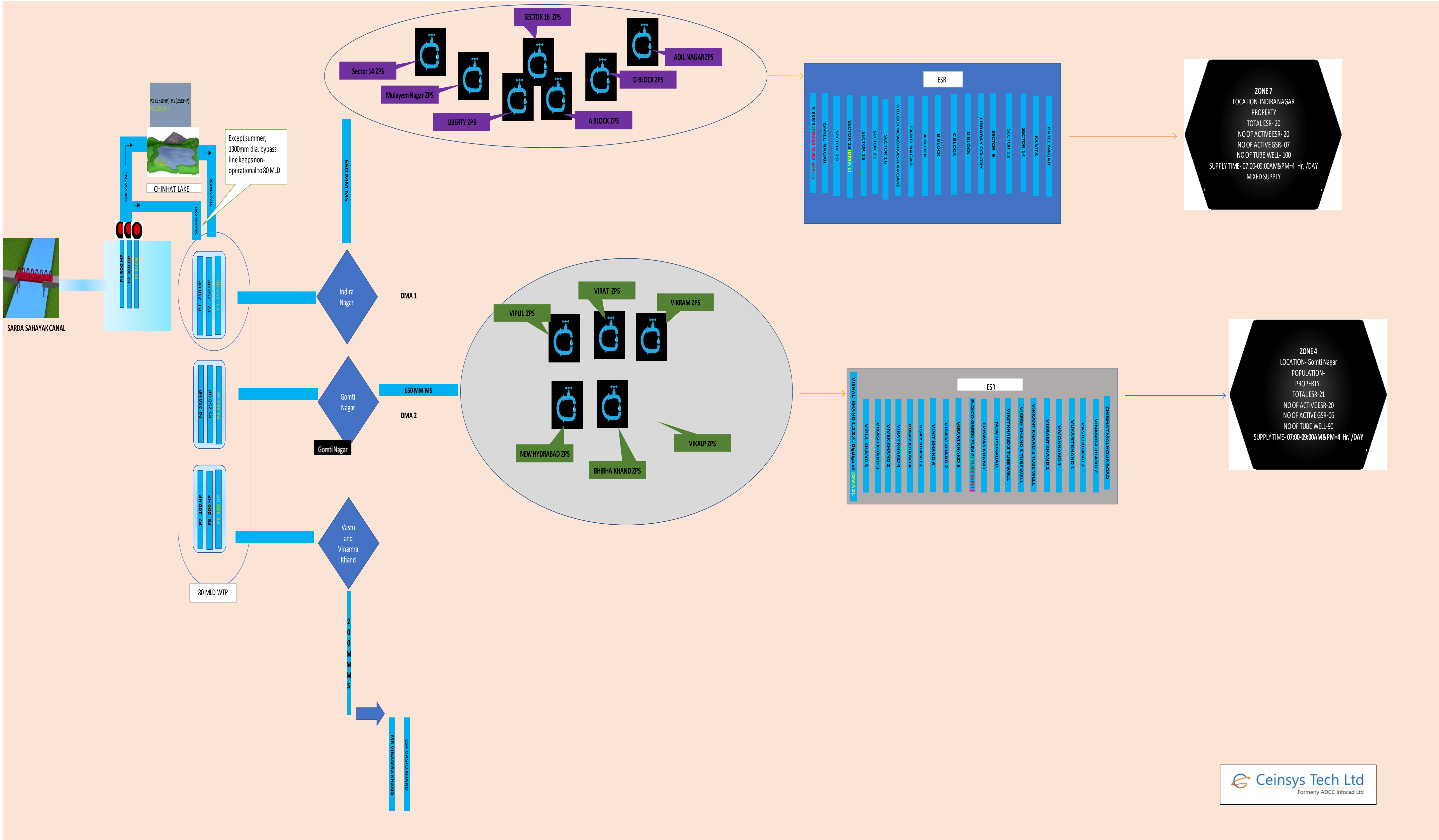
12.15.1 AISHBAGH WTP



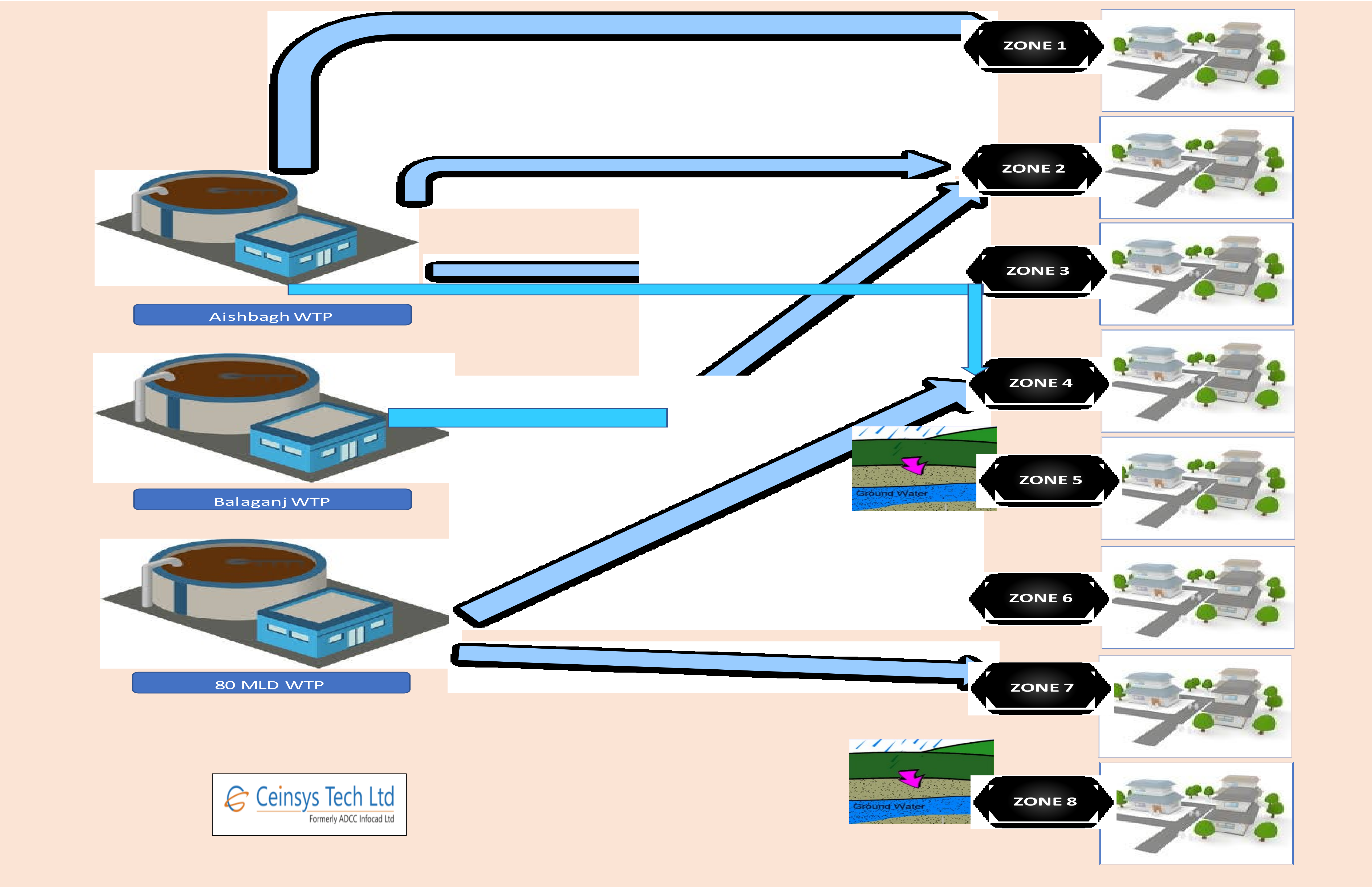
12.15.2 BALAGANJ WTP



12.15.3GOMTI NAGAR WATER SUPPLY SYSTEM (80 MLD)



12.15.4ZONAL FLOW DIAGRAM



PART-5

HYDRULIC MODELLING REPORT OF SAMPLE DMAs

SUMMARY

This report describes the development of the hydraulic model used to evaluate the water distribution system adequacy under existing demand conditions. Data used to develop the model was provided by the Town and was based primarily on the existing water distribution system pipe schematic map. Temporary Bulk meters are installed on selected DMAs. The calibrated and validated model was used to identify water system deficiencies. The exact data regarding interconnection of pipes for isolation of zones is available with council which was required to calibrate the entire hydraulic model. Also LMC didn't having database of asset mapping & conditions. Hence calibration is done on the selected sample DMAs. The conclusion is based on the analysis of the sample DMAs. From these results we can understand the approximate exsisting ground reality & efficiency of the network system. Hence it is strongly recommended to do the hydraulic modelling of entire sytem after collection of exact netwaork asset mapping. The software used to simulate the water distribution system was Water GEMS® Version 6.0.

MODEL CALIBRATION

Model Calibration generally involves simulating flows in the pipes and pressure for junction in the model; comparing the field results against model results; and making adjustments or corrections to the model, as required, to closely matching the computed system response with actual field data.

DATA INPUT FOR CALIBRATION

The model is calibrated using the data from field and performing actual calibration to meet the ground condition. The readings are taken at all sample DMAs.

The parameters considered for calibration are as follows:

Flow

Pressure

Supply Hours

C-value

Head-loss

The following table shows the supply hours & readings for flow at respective DMA.

Sr. No	DMA Name	Supply Hours	Flow in MLD
1	Indra Nagar	6.00	0.53
2	Gomti Nagar	6.00	2.18
3	Rajajipuram	6.00	1.66
4	Aliganj Sec-B	3	1.87
5	Jiya Mau	3	1.28
6	Eldico	5	1.47
7	Ruchi Khand	5	3.47
8	Vastu Khand	5	2.06
9	Viram Khand	5	2.35
10			
11			

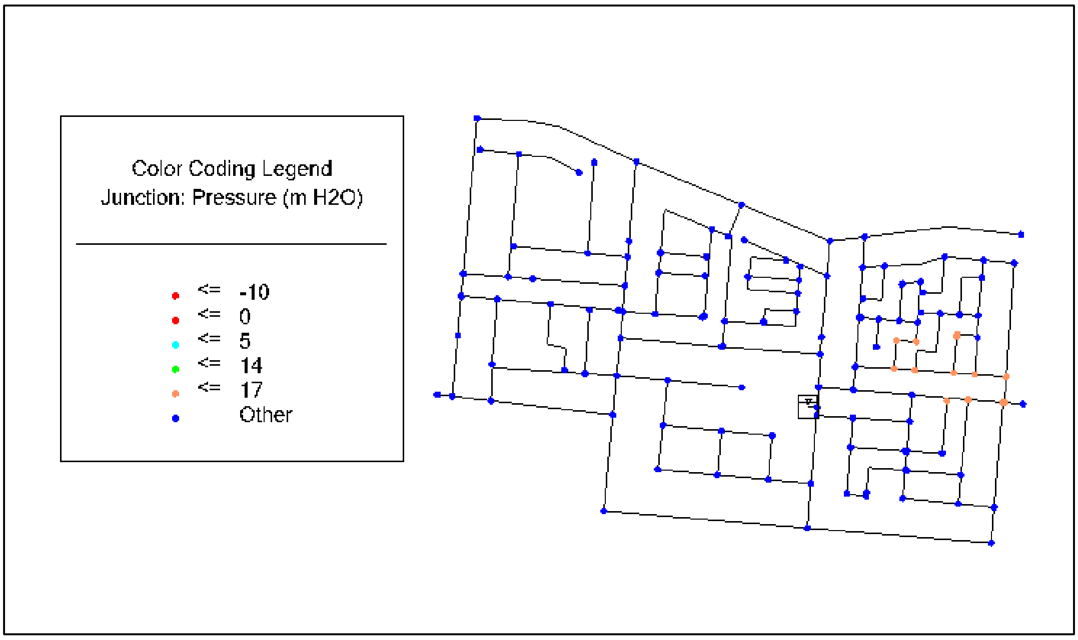
RUNNING THE CALIBRATION SCENARIO

For Calibration of hydraulic model, the flow meter readings are taken at the outlet of Reservoirs. In case of all DMAs, supply was done for 3-6 hours every alternate day, during water audit study. It means the demand for 2 days is supplied in 3-6 hours. In that scenario, peak factor will be much higher.

The physical alternatives are made by considering actual working pattern. To simulate ground condition, the DMAs are isolated and the remaining network on the main line is made inactive. Peak factor is applied to respective DMA.

Indra Nagar DMA

In case of Indra Nagar DMA, the total flow through this DMA is 0.53 MLD. This demand is applied to that DMA. As the supply for this DMA is for 6.00 hours, the peak factor is 4.



The results of calibration are presented in table below:

Pipe results for Indra Nagar DMA

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-30	1	J-143	J-144	69.8	PVC	80	0	0	0	0	0	0	0
Pipeline_1-132	1	J-147	J-148	300	AC	60	174.87	0.03	0.017	0.03	0.02	0.01	0
Pipeline_1-156	2	J-161	J-162	200	AC	60	143.46	0.05	0.095	0.1	0.1	0.06	0.01
Pipeline_1-4	10	T-1	J-164	300	AC	60	2129	0.35	2.01	2.5	2.01	1.18	0.15
Pipeline_1-16	9	J-164	J-165	250	AC	60	458.17	0.11	0.284	0.37	0.28	0.17	0.02
Pipeline_1-9	15	J-168	J-169	69.8	PVC	80	35.78	0.11	0.741	0.61	0.74	0.44	0.06
Pipeline_1-7	16	J-170	J-168	69.8	PVC	80	2.02	0.01	0.004	0	0	0	0

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-72	17	J-171	J-172	69.8	PVC	80	2.17	0.01	0.004	0	0	0	0
Pipeline_1-116	18	J-173	J-174	116.4	PVC	80	145.49	0.16	0.825	0.62	0.83	0.48	0.06
Pipeline_1-130	19	J-175	J-176	200	AC	60	190.31	0.07	0.166	0.23	0.17	0.1	0.01
Pipeline_1-90	20	J-177	J-178	69.8	PVC	80	35.78	0.11	0.741	0.51	0.74	0.44	0.06
Pipeline_1-84	20	J-179	J-180	69.8	PVC	80	2.54	0.01	0.005	0.01	0.01	0	0
Pipeline_1-39	20	J-181	J-182	69.8	PVC	80	122.19	0.37	7.209	5.97	7.21	4.23	0.55
Pipeline_1-81	20	J-183	J-184	69.8	PVC	80	2.57	0.01	0.006	0.01	0.01	0	0
Pipeline_1-10	20	J-169	J-185	69.8	PVC	80	58.56	0.18	1.846	1.53	1.85	1.08	0.14

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-155	21	J-162	J-186	200	AC	60	2.66	0	0	0	0	0	0
Pipeline_1-50	21	J-187	J-188	69.8	PVC	80	32.27	0.1	0.612	0.51	0.61	0.36	0.05
Pipeline_1-48	21	J-189	J-190	69.8	PVC	80	8.27	0.02	0.049	0.06	0.05	0.03	0
Pipeline_1-47	21	J-190	J-191	69.8	PVC	80	14.46	0.04	0.138	0.17	0.14	0.08	0.01
Pipeline_1-19	21	J-192	J-193	102.6	PVC	80	42.26	0.06	0.154	0.19	0.15	0.09	0.01
Pipeline_1-139	22	J-194	J-195	69.8	PVC	80	2.86	0.01	0.007	0.01	0.01	0	0
Pipeline_1-85	22	J-191	J-196	69.8	PVC	80	2.8	0.01	0.006	0.01	0.01	0	0
Pipeline_1-107	22	J-197	J-198	102.6	PVC	80	60.39	0.08	0.299	0.4	0.3	0.18	0.02

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-51	22	J-198	J-187	102.6	PVC	80	54.71	0.08	0.249	0.33	0.25	0.15	0.02
Pipeline_1-24	23	J-199	J-200	69.8	PVC	80	51.11	0.15	1.435	1.19	1.44	0.84	0.11
Pipeline_1-49	23	J-188	J-179	69.8	PVC	80	16.16	0.05	0.17	0.14	0.17	0.1	0.01
Pipeline_1-3	23	J-164	J-201	300	AC	60	1664.07	0.27	1.274	1.56	1.27	0.75	0.1
Pipeline_1-54	23	J-202	J-203	102.6	PVC	80	48.22	0.07	0.197	0.43	0.2	0.12	0.02
Pipeline_1-52	24	J-205	J-206	102.6	PVC	80	24.91	0.03	0.058	0.03	0.06	0.03	0
Pipeline_1-44	24	J-207	J-208	102.6	PVC	80	60.58	0.08	0.301	0.45	0.3	0.18	0.02
Pipeline_1-37	25	J-209	J-210	102.6	PVC	80	80.39	0.11	0.508	0.57	0.51	0.3	0.04

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-120	26	J-211	J-212	116.4	PVC	80	250.87	0.27	2.263	2.04	2.26	1.33	0.17
Pipeline_1-148	116	J-168	J-146	69.8	PVC	80	14.91	0.05	0.147	0.12	0.15	0.09	0.01
Pipeline_1-38	28	J-213	J-214	102.6	PVC	80	200.16	0.28	2.754	3.4	2.75	1.62	0.21
Pipeline_1-1	28	J-148	J-216	69.8	PVC	80	171.12	0.52	13.45	11.48	13.45	7.9	1.02
Pipeline_1-15	29	J-162	J-217	102.6	PVC	80	134.16	0.19	1.313	1.33	1.31	0.77	0.1
Pipeline_1-17	30	J-218	J-219	102.6	PVC	80	41.63	0.06	0.15	0.11	0.15	0.09	0.01
Pipeline_1-118	32	J-202	J-197	116.4	PVC	80	67.3	0.07	0.198	0.16	0.2	0.12	0.02
Pipeline_1-83	32	J-179	J-220	69.8	PVC	80	4.07	0.01	0.013	0.01	0.01	0.01	0

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-143	44	J-189	J-221	69.8	PVC	80	5.72	0.02	0.025	0.02	0.03	0.02	0
Pipeline_1-108	32	J-193	J-222	102.6	PVC	80	17.46	0.02	0.03	0.03	0.03	0.02	0
Pipeline_1-23	33	J-223	J-173	116.4	PVC	80	211.4	0.23	1.648	1.28	1.65	0.97	0.13
Pipeline_1-109	33	J-224	J-225	102.6	PVC	80	4.55	0.01	0.002	0	0	0	0
Pipeline_1-6	33	J-226	J-227	116.4	PVC	80	39.11	0.04	0.072	0.06	0.07	0.04	0.01
Pipeline_1-18	34	J-219	J-192	102.6	PVC	80	74.74	0.1	0.444	0.57	0.44	0.26	0.03
Pipeline_1-135	34	J-177	J-228	102.6	PVC	80	45.08	0.06	0.174	0.17	0.17	0.1	0.01
Pipeline_1-157	34	J-207	J-229	102.6	PVC	80	16.58	0.02	0.027	0.01	0.03	0.02	0

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-11	50	J-167	J-185	69.8	PVC	80	6.4	0.02	0.031	0.03	0.03	0.02	0
Pipeline_1-104	35	J-206	J-217	102.6	PVC	80	43.2	0.06	0.161	0.12	0.16	0.09	0.01
Pipeline_1-34	35	J-230	J-231	69.8	PVC	80	83.41	0.25	3.554	3.18	3.55	2.09	0.27
Pipeline_1-124	36	J-232	J-233	116.4	PVC	80	4.66	0.01	0.001	0	0	0	0
Pipeline_1-2	37	J-201	J-175	300	AC	60	1084.53	0.18	0.576	0.72	0.58	0.34	0.04
Pipeline_1-97	38	J-181	J-234	69.8	PVC	80	86.28	0.26	3.784	2.94	3.78	2.22	0.29
Pipeline_1-55	39	J-201	J-211	200	AC	60	566.75	0.21	1.249	1.46	1.25	0.73	0.1
Pipeline_1-128	39	J-235	J-161	200	AC	60	177.48	0.07	0.145	0.15	0.15	0.09	0.01

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-5	39	J-192	J-236	69.8	PVC	80	20.33	0.06	0.26	0.22	0.26	0.15	0.02
Pipeline_1-43	39	J-237	J-229	69.8	PVC	80	38.19	0.12	0.837	0.95	0.84	0.49	0.06
Pipeline_1-115	40	J-238	J-237	116.4	PVC	80	138.84	0.15	0.756	0.73	0.76	0.44	0.06
Pipeline_1-92	70	J-193	J-215	69.8	PVC	80	8.96	0.03	0.057	0.05	0.06	0.03	0
Pipeline_1-21	40	J-225	J-239	69.8	PVC	80	7.59	0.02	0.041	0.07	0.04	0.02	0
Pipeline_1-14	40	J-239	J-240	102.6	PVC	80	19.81	0.03	0.038	0.06	0.04	0.02	0
Pipeline_1-36	40	J-210	J-241	69.8	PVC	80	82.43	0.25	3.477	2.88	3.48	2.04	0.27
Pipeline_1-82	41	J-188	J-242	69.8	PVC	80	5.23	0.02	0.021	0.02	0.02	0.01	0

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-122	41	J-226	J-165	116.4	PVC	80	106.38	0.12	0.462	0.45	0.46	0.27	0.04
Pipeline_1-86	41	J-206	J-243	69.8	PVC	80	5.35	0.02	0.022	0.02	0.02	0.01	0
Pipeline_1-87	42	J-205	J-244	69.8	PVC	80	5.35	0.02	0.022	0.02	0.02	0.01	0
Pipeline_1-88	66	J-178	J-190	69.8	PVC	80	7.74	0.02	0.043	0.02	0.04	0.03	0
Pipeline_1-129	43	J-245	J-230	200	AC	60	187.55	0.07	0.161	0.21	0.16	0.1	0.01
Pipeline_1-158	43	J-178	J-189	69.8	PVC	80	11.47	0.03	0.09	0.06	0.09	0.05	0.01
Pipeline_1-53	43	J-203	J-205	102.6	PVC	80	5.58	0.01	0.004	0.01	0	0	0
Pipeline_1-119	43	J-212	J-202	116.4	PVC	80	128.2	0.14	0.652	0.66	0.65	0.38	0.05

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-70	44	J-246	J-247	69.8	PVC	80	5.63	0.02	0.024	0.02	0.02	0.01	0
Pipeline_1-33	44	J-248	J-171	69.8	PVC	80	49.76	0.15	1.366	1.45	1.37	0.8	0.1
Pipeline_1-144	58	J-208	J-249	69.8	PVC	80	7.54	0.02	0.042	0.03	0.04	0.02	0
Pipeline_1-46	44	J-250	J-177	102.6	PVC	80	3.33	0	0.001	0.01	0	0	0
Pipeline_1-65	90	J-251	J-204	69.8	PVC	80	11.6	0.04	0.092	0.08	0.09	0.05	0.01
Pipeline_1-31	45	J-230	J-252	69.8	PVC	80	60.03	0.18	1.933	1.75	1.93	1.14	0.15
Pipeline_1-101	45	J-210	J-253	102.6	PVC	80	16.28	0.02	0.026	0.07	0.03	0.02	0
Pipeline_1-22	45	J-173	J-254	69.8	PVC	80	53.64	0.16	1.569	1.3	1.57	0.92	0.12

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-106	46	J-187	J-183	102.6	PVC	80	11.02	0.02	0.013	0.02	0.01	0.01	0
Pipeline_1-137	47	J-200	J-232	69.8	PVC	80	28.96	0.09	0.501	0.42	0.5	0.29	0.04
Pipeline_1-145	61	J-250	J-255	69.8	PVC	80	7.88	0.02	0.045	0.04	0.05	0.03	0
Pipeline_1-27	48	J-256	J-257	102.6	PVC	80	129.26	0.18	1.225	1.66	1.23	0.72	0.09
Pipeline_1-78	50	J-258	J-257	69.8	PVC	80	31.2	0.09	0.575	0.6	0.58	0.34	0.04
Pipeline_1-79	50	J-259	J-260	69.8	PVC	80	19.64	0.06	0.244	0.18	0.24	0.14	0.02
Pipeline_1-80	50	J-261	J-262	69.8	PVC	80	21.07	0.06	0.278	0.2	0.28	0.16	0.02
Pipeline_1-102	50	J-214	J-209	102.6	PVC	80	124.66	0.17	1.146	1.35	1.15	0.67	0.09

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-125	50	J-256	J-263	116.4	PVC	80	183.67	0.2	1.27	1.09	1.27	0.75	0.1
Pipeline_1-99	51	J-144	J-261	69.8	PVC	80	14.49	0.04	0.139	0.14	0.14	0.08	0.01
Pipeline_1-96	51	J-264	J-199	69.8	PVC	80	6.6	0.02	0.032	0.03	0.03	0.02	0
Pipeline_1-95	51	J-265	J-200	69.8	PVC	80	6.61	0.02	0.032	0.03	0.03	0.02	0
Pipeline_1-121	52	J-227	J-194	116.4	PVC	80	12.46	0.01	0.009	0.01	0.01	0.01	0
Pipeline_1-123	53	J-232	J-266	116.4	PVC	80	6.82	0.01	0.003	0	0	0	0
Pipeline_1-117	56	J-212	J-267	116.4	PVC	80	106.54	0.12	0.463	0.36	0.46	0.27	0.04
Pipeline_1-8	71	J-166	J-169	69.8	PVC	80	9.13	0.03	0.059	0.05	0.06	0.04	0.01

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-105	57	J-267	J-207	102.6	PVC	80	92.05	0.13	0.653	0.81	0.65	0.38	0.05
Pipeline_1-98	57	J-259	J-258	69.8	PVC	80	17.45	0.05	0.196	0.24	0.2	0.12	0.02
Pipeline_1-26	57	J-257	J-260	102.6	PVC	80	78.2	0.11	0.483	0.6	0.48	0.28	0.04
Pipeline_1-29	57	J-230	J-144	102.6	PVC	80	20.89	0.03	0.042	0.05	0.04	0.03	0
Pipeline_1-127	59	J-245	J-223	200	AC	60	453.54	0.17	0.827	0.97	0.83	0.49	0.06
Pipeline_1-76	59	J-236	J-268	69.8	PVC	80	7.64	0.02	0.042	0.04	0.04	0.03	0
Pipeline_1-35	60	J-241	J-251	69.8	PVC	80	50.53	0.15	1.405	1.16	1.41	0.83	0.11
Pipeline_1-77	60	J-224	J-269	69.8	PVC	80	7.77	0.02	0.044	0.04	0.04	0.03	0

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-93	61	J-270	J-227	69.8	PVC	80	7.82	0.02	0.044	0.04	0.04	0.03	0
Pipeline_1-59	62	J-222	J-225	69.8	PVC	80	5.31	0.02	0.022	0.01	0.02	0.01	0
Pipeline_1-57	63	J-218	J-235	200	AC	60	236.91	0.09	0.248	0.26	0.25	0.15	0.02
Pipeline_1-25	105	J-182	J-199	69.8	PVC	80	80.79	0.24	3.35	2.77	3.35	1.97	0.26
Pipeline_1-94	64	J-219	J-226	69.8	PVC	80	49.54	0.15	1.354	1.57	1.35	0.8	0.1
Pipeline_1-28	65	J-261	J-259	69.8	PVC	80	14.88	0.04	0.145	0.17	0.15	0.09	0.01
Pipeline_1-56	66	J-211	J-218	200	AC	60	299.02	0.11	0.382	0.39	0.38	0.22	0.03
Pipeline_1-111	67	J-260	J-262	102.6	PVC	80	36.16	0.05	0.116	0.14	0.12	0.07	0.01

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-45	68	J-208	J-250	102.6	PVC	80	33.57	0.05	0.101	0.16	0.1	0.06	0.01
Pipeline_1-68	69	J-253	J-171	69.8	PVC	80	30.91	0.09	0.565	0.69	0.57	0.33	0.04
Pipeline_1-126	69	J-176	J-238	116.4	PVC	80	178.88	0.19	1.209	1.13	1.21	0.71	0.09
Pipeline_1-142	87	J-203	J-191	69.8	PVC	80	34.01	0.1	0.675	0.67	0.68	0.4	0.05
Pipeline_1-69	72	J-246	J-271	69.8	PVC	80	9.22	0.03	0.06	0.05	0.06	0.04	0.01
Pipeline_1-62	72	J-231	J-272	69.8	PVC	80	9.28	0.03	0.061	0.05	0.06	0.04	0.01
Pipeline_1-66	74	J-241	J-273	69.8	PVC	80	9.49	0.03	0.064	0.05	0.06	0.04	0.01
Pipeline_1-67	76	J-251	J-274	69.8	PVC	80	9.81	0.03	0.068	0.06	0.07	0.04	0.01

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-134	77	J-165	J-256	250	AC	60	335.44	0.08	0.159	0.2	0.16	0.09	0.01
Pipeline_1-147	96	J-185	J-216	69.8	PVC	80	86.36	0.26	3.791	3.14	3.79	2.23	0.29
Pipeline_1-112	83	J-144	J-275	102.6	PVC	80	10.71	0.01	0.012	0.02	0.01	0.01	0
Pipeline_1-61	83	J-254	J-276	69.8	PVC	80	10.71	0.03	0.079	0.07	0.08	0.05	0.01
Pipeline_1-58	85	J-235	J-224	102.6	PVC	80	35.32	0.05	0.111	0.14	0.11	0.07	0.01
Pipeline_1-136	90	J-174	J-277	102.6	PVC	80	131.59	0.18	1.266	1.52	1.27	0.74	0.1
Pipeline_1-40	98	J-216	J-181	69.8	PVC	80	56.09	0.17	1.705	1.55	1.71	1	0.13
Pipeline_1-154	98	J-182	J-278	69.8	PVC	80	12.66	0.04	0.108	0.09	0.11	0.06	0.01

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-113	101	J-238	J-279	102.6	PVC	80	13	0.02	0.017	0.02	0.02	0.01	0
Pipeline_1-60	103	J-254	J-280	69.8	PVC	80	13.23	0.04	0.117	0.1	0.12	0.07	0.01
Pipeline_1-114	103	J-223	J-213	116.4	PVC	80	217.03	0.24	1.73	1.34	1.73	1.02	0.13
Pipeline_1-42	107	J-234	J-237	69.8	PVC	80	76.72	0.23	3.045	2.82	3.05	1.79	0.23
Pipeline_1-13	109	J-252	J-281	69.8	PVC	80	26.26	0.08	0.418	0.36	0.42	0.25	0.03
Pipeline_1-146	140	J-231	J-248	69.8	PVC	80	42.22	0.13	1.007	0.97	1.01	0.59	0.08
Pipeline_1-131	113	J-282	J-245	300	AC	60	668.76	0.11	0.235	0.29	0.24	0.14	0.02
Pipeline_1-20	119	J-161	J-239	102.6	PVC	80	13.47	0.02	0.019	0.03	0.02	0.01	0

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-41	127	J-277	J-234	69.8	PVC	80	44.62	0.13	1.116	0.65	1.12	0.66	0.09
Pipeline_1-103	129	J-217	J-228	102.6	PVC	80	66.07	0.09	0.353	0.38	0.35	0.21	0.03
Pipeline_1-32	137	J-252	J-248	69.8	PVC	80	48.89	0.15	1.322	1.25	1.32	0.78	0.1
Pipeline_1-71	139	J-214	J-246	69.8	PVC	80	47.57	0.14	1.256	1.04	1.26	0.74	0.1
Pipeline_1-138	176	J-229	J-283	69.8	PVC	80	22.64	0.07	0.318	0.26	0.32	0.19	0.02
Pipeline_1-100	176	J-209	J-284	102.6	PVC	80	11.9	0.02	0.015	0.02	0.02	0.01	0
Pipeline_1-153	187	J-277	J-284	69.8	PVC	80	34.86	0.11	0.707	0.61	0.71	0.42	0.05
Pipeline_1-110	206	J-240	J-263	102.6	PVC	80	51.57	0.07	0.223	0.33	0.22	0.13	0.02

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_1-12	228	J-263	J-281	102.6	PVC	80	69.66	0.1	0.39	0.53	0.39	0.23	0.03
P-3	110	J-175	J-147	300	AC	60	872.77	0.14	0.385	0.47	0.39	0.23	0.03
P-4	1	J-147	J-282	300	AC	60	683.49	0.11	0.247	0.3	0.25	0.14	0.02

Node/ Junction results for Indra Nagar DMA

Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm^2)At present condition	Pressure (kg/cm^2) 4 Hours Supply	Pressure (kg/cm^2) 6 Hours Supply	Pressure (kg/cm^2) 8 Hours Supply	Pressure (kg/cm^2) 24 Hours Supply
J-143	121.7	0	137.83	1.9	1.59	1.9	1.9	1.91
J-144	121.7	6.14	137.83	1.9	1.59	1.9	1.9	1.91
J-146	120	3.71	137.81	1.99	1.7	1.99	2.03	2.07
J-147	120.8	3.59	137.83	1.99	1.69	1.99	1.99	2
J-148	120.8	0.94	137.83	1.99	1.69	1.99	1.99	2
J-161	123.9	5.12	137.83	1.68	1.37	1.68	1.68	1.69
J-162	123.9	1.65	137.83	1.68	1.37	1.68	1.68	1.69
J-164	122	1.68	137.84	1.88	1.58	1.88	1.88	1.88
J-165	122	4.07	137.84	1.88	1.58	1.88	1.88	1.88
J-166	119.3	2.27	137.81	2.06	1.77	2.06	2.1	2.14
J-167	120.2	1.59	137.81	1.97	1.68	1.97	2.01	2.05
J-168	119.9	4.69	137.81	2	1.71	2	2.04	2.08
J-169	120	3.4	137.81	1.99	1.7	1.99	2.03	2.07
J-170	120.1	0.5	137.81	1.98	1.69	1.98	2.02	2.06
J-171	119.3	4.15	137.82	2.1	1.8	2.1	2.12	2.15
J-172	119.3	0.54	137.82	2.1	1.8	2.1	2.12	2.15
J-173	120.8	3.05	137.83	1.98	1.67	1.98	1.99	2
J-174	120.7	3.46	137.83	1.98	1.68	1.98	1.99	2.01
J-175	121.8	5.34	137.84	1.89	1.59	1.89	1.9	1.9
J-176	121.5	2.85	137.84	1.92	1.62	1.92	1.93	1.93
J-177	121.6	3.14	137.83	1.9	1.59	1.9	1.91	1.92
J-178	121.7	4.12	137.83	1.89	1.58	1.89	1.9	1.91
J-179	123	2.38	137.83	1.76	1.46	1.76	1.77	1.78
J-180	122.4	0.63	137.83	1.82	1.52	1.82	1.83	1.84
J-181	120.2	5.02	137.82	1.99	1.7	1.99	2.02	2.05
J-182	120.3	7.16	137.81	1.97	1.68	1.97	2	2.04
J-183	122.6	2.1	137.83	1.8	1.5	1.8	1.81	1.82
J-184	122.8	0.64	137.83	1.78	1.48	1.78	1.79	1.8
J-185	120.4	5.33	137.81	1.95	1.66	1.95	1.99	2.03
J-186	123.4	0.66	137.83	1.73	1.42	1.73	1.73	1.74
J-187	123.4	2.85	137.83	1.72	1.42	1.72	1.73	1.74

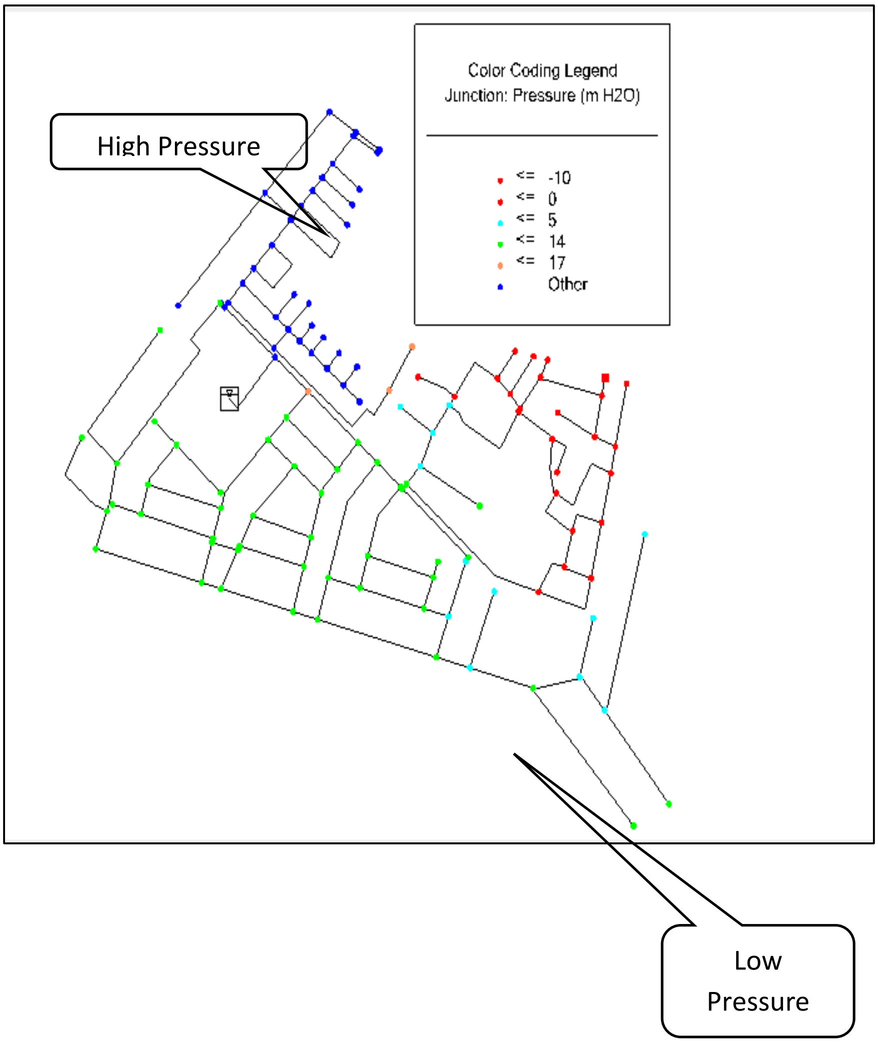
Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm^2)At present condition	Pressure (kg/cm^2) 4 Hours Supply	Pressure (kg/cm^2) 6 Hours Supply	Pressure (kg/cm^2) 8 Hours Supply	Pressure (kg/cm^2) 24 Hours Supply
J-188	123.4	2.71	137.83	1.72	1.42	1.72	1.73	1.74
J-189	122.8	3.49	137.83	1.78	1.47	1.78	1.79	1.8
J-190	123.1	3.47	137.83	1.75	1.44	1.75	1.76	1.77
J-191	123.1	4.17	137.83	1.75	1.44	1.75	1.76	1.77
J-192	121.2	3.03	137.83	1.95	1.64	1.95	1.95	1.96
J-193	121.5	3.94	137.83	1.92	1.61	1.92	1.92	1.93
J-194	122.5	2.39	137.84	1.83	1.53	1.83	1.83	1.83
J-195	122.2	0.71	137.84	1.86	1.56	1.86	1.86	1.86
J-196	123.2	0.7	137.83	1.74	1.43	1.74	1.75	1.76
J-197	123.7	1.72	137.83	1.69	1.39	1.69	1.7	1.71
J-198	123.8	1.42	137.83	1.68	1.38	1.68	1.69	1.7
J-199	120.6	5.75	137.8	1.9	1.62	1.9	1.95	2.01
J-200	120.9	3.87	137.8	1.87	1.59	1.87	1.92	1.98
J-201	122	3.18	137.84	1.88	1.57	1.88	1.88	1.88
J-202	124	3.16	137.83	1.66	1.36	1.66	1.67	1.68
J-203	124.3	4.93	137.83	1.63	1.33	1.63	1.64	1.65
J-204	120.6	2.89	137.81	1.95	1.65	1.95	1.98	2.01
J-205	124.8	3.48	137.83	1.58	1.28	1.58	1.59	1.6
J-206	124.7	3.22	137.83	1.59	1.29	1.59	1.6	1.61
J-207	122	3.71	137.83	1.86	1.56	1.86	1.87	1.88
J-208	122.8	4.85	137.83	1.78	1.48	1.78	1.79	1.8
J-209	120.6	8.06	137.82	1.97	1.67	1.97	1.99	2.02
J-210	120.6	3.55	137.82	1.97	1.67	1.97	1.99	2.02
J-211	122.5	4.2	137.84	1.82	1.52	1.82	1.82	1.83
J-212	123.1	4.02	137.83	1.75	1.45	1.75	1.76	1.77
J-213	120.2	4.2	137.83	2.02	1.72	2.02	2.04	2.06
J-214	120.1	6.95	137.82	2.03	1.72	2.03	2.04	2.07
J-215	122	2.23	137.83	1.87	1.56	1.87	1.87	1.88
J-216	120.2	7.14	137.82	2.01	1.71	2.01	2.03	2.06
J-217	123.8	6.2	137.83	1.68	1.38	1.68	1.69	1.7
J-218	123.4	5.1	137.83	1.73	1.43	1.73	1.73	1.74
J-219	122.4	4.09	137.83	1.83	1.53	1.83	1.83	1.84
J-220	123.4	1.01	137.83	1.72	1.42	1.72	1.73	1.74

Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm^2)At present condition	Pressure (kg/cm^2) 4 Hours Supply	Pressure (kg/cm^2) 6 Hours Supply	Pressure (kg/cm^2) 8 Hours Supply	Pressure (kg/cm^2) 24 Hours Supply
J-221	123.8	1.43	137.83	1.68	1.37	1.68	1.69	1.7
J-222	121.9	3.02	137.83	1.88	1.57	1.88	1.88	1.89
J-223	121	6.25	137.83	1.96	1.66	1.96	1.97	1.98
J-224	123.7	5.73	137.83	1.7	1.39	1.7	1.7	1.71
J-225	122.3	4.35	137.83	1.84	1.53	1.84	1.84	1.85
J-226	121.8	4.41	137.84	1.9	1.6	1.9	1.9	1.9
J-227	121.1	4.69	137.84	1.97	1.67	1.97	1.97	1.97
J-228	121.4	5.23	137.83	1.92	1.62	1.92	1.93	1.94
J-229	122.2	8	137.83	1.84	1.54	1.84	1.85	1.86
J-230	121.3	5.78	137.83	1.94	1.63	1.94	1.94	1.95
J-231	120.9	7.94	137.83	1.96	1.66	1.96	1.97	1.99
J-232	121.3	4.35	137.8	1.83	1.54	1.83	1.88	1.94
J-233	121.1	1.16	137.8	1.85	1.56	1.85	1.9	1.96
J-234	121	8.73	137.82	1.93	1.63	1.93	1.95	1.98
J-235	124.9	6	137.83	1.58	1.28	1.58	1.58	1.59
J-236	123.5	3.16	137.83	1.72	1.41	1.72	1.72	1.73
J-237	121	5.96	137.83	1.96	1.66	1.96	1.97	1.98
J-238	120.6	6.73	137.83	2	1.7	2	2.01	2.02
J-239	121.6	6.4	137.83	1.91	1.6	1.91	1.91	1.92
J-240	120.9	7.91	137.83	1.98	1.67	1.98	1.98	1.99
J-241	120.2	5.58	137.82	1.99	1.69	1.99	2.02	2.05
J-242	122.8	1.3	137.83	1.78	1.48	1.78	1.79	1.8
J-243	123.6	1.33	137.83	1.7	1.4	1.7	1.71	1.72
J-244	123.8	1.33	137.83	1.68	1.38	1.68	1.69	1.7
J-245	121.2	6.89	137.83	1.95	1.64	1.95	1.95	1.96
J-246	119.4	8.15	137.82	2.08	1.78	2.08	2.1	2.13
J-247	118.6	1.4	137.82	2.16	1.86	2.16	2.18	2.21
J-248	119.3	10.29	137.82	2.11	1.81	2.11	2.13	2.15
J-249	122.2	1.88	137.83	1.84	1.54	1.84	1.85	1.86
J-250	122	5.57	137.83	1.86	1.55	1.86	1.87	1.88
J-251	120.4	7.25	137.81	1.97	1.67	1.97	2	2.03
J-252	121	9.31	137.83	1.96	1.65	1.96	1.97	1.98
J-253	119.8	3.64	137.82	2.05	1.75	2.05	2.07	2.1

Label	Elevation (m)	Demand (m³/day)	Hydraulic Grade (m)	Pressure (kg/cm²)At present condition	Pressure (kg/cm²) 4 Hours Supply	Pressure (kg/cm²) 6 Hours Supply	Pressure (kg/cm²) 8 Hours Supply	Pressure (kg/cm²) 24 Hours Supply
J-254	120.9	7.4	137.83	1.96	1.66	1.96	1.97	1.99
J-255	122.7	1.96	137.83	1.79	1.48	1.79	1.8	1.81
J-256	122.7	5.6	137.84	1.81	1.51	1.81	1.81	1.81
J-257	121	4.95	137.84	1.97	1.67	1.97	1.97	1.98
J-258	120.9	3.42	137.83	1.98	1.68	1.98	1.98	1.99
J-259	120.3	5.53	137.83	2.04	1.73	2.04	2.04	2.05
J-260	120.2	5.58	137.83	2.05	1.74	2.05	2.05	2.06
J-261	120.6	5.34	137.83	2.01	1.7	2.01	2.01	2.02
J-262	120.6	3.75	137.83	2.01	1.7	2.01	2.01	2.02
J-263	123.5	15.55	137.84	1.72	1.42	1.72	1.72	1.73
J-264	120.1	1.64	137.8	1.95	1.67	1.95	2	2.06
J-265	120	1.65	137.8	1.96	1.68	1.96	2.01	2.07
J-266	120.6	1.7	137.8	1.9	1.61	1.9	1.95	2.01
J-267	122.3	3.61	137.83	1.83	1.53	1.83	1.84	1.85
J-268	124.4	1.9	137.83	1.63	1.32	1.63	1.63	1.64
J-269	121.6	1.93	137.83	1.91	1.6	1.91	1.91	1.92
J-270	121.1	1.95	137.84	1.97	1.67	1.97	1.97	1.97
J-271	119.8	2.29	137.82	2.04	1.74	2.04	2.06	2.1
J-272	121	2.31	137.83	1.95	1.65	1.95	1.96	1.98
J-273	119.7	2.36	137.82	2.04	1.74	2.04	2.07	2.1
J-274	121.1	2.44	137.81	1.9	1.6	1.9	1.93	1.96
J-275	120.8	2.67	137.83	1.98	1.68	1.98	1.99	2
J-276	120	2.67	137.83	2.05	1.75	2.05	2.06	2.08
J-277	118.9	12.97	137.82	2.15	1.85	2.15	2.17	2.19
J-278	120.6	3.15	137.81	1.94	1.65	1.94	1.97	2.01
J-279	120.1	3.24	137.83	2.05	1.75	2.05	2.06	2.07
J-280	119.5	3.29	137.83	2.1	1.8	2.1	2.11	2.13
J-281	122.4	10.8	137.83	1.82	1.52	1.82	1.83	1.84
J-282	120.8	3.67	137.83	1.99	1.69	1.99	1.99	2
J-283	121.6	5.64	137.83	1.89	1.59	1.89	1.9	1.92
J-284	118	11.64	137.82	2.23	1.93	2.23	2.25	2.28

Gomti Nagar DMA

In case of Gomti Nagar DMA, the total flow through this DMA is 2.18 MLD. This demand is applied to that DMA. As the supply for this DMA is for 6.00 hours, the peak factor is 4.



The results of calibration are presented in table below:

Pipe results for Gomti Nagar DMA

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-144	0	J-285	J-286	69.8	PVC	80	0.01	0	0	0	0	0	0
Pipeline_2-23	0	J-287	J-288	102.6	PVC	80	9.55	0.01	0	0	0	0	0
Pipeline_2-25	0	J-288	J-287	300	AC	60	96.17	0.02	0	0	0	0	0
Pipeline_2-48	0	J-289	J-290	69.8	PVC	80	0.05	0	0	0	0	0	0
Pipeline_2-113	1	J-291	J-292	149.2	PVC	80	0.21	0	0	0	0	0	0
Pipeline_2-38	1	J-291	J-292	149.2	PVC	80	0.21	0	0	0	0	0	0
Pipeline_2-124	0	J-288	J-287	300	AC	60	96.17	0.02	0	0	0	0	0

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-20	2	J-299	J-300	102.6	PVC	80	158.64	0.22	1.791	5.21	1.79	1.05	0.14
Pipeline_2-119	3	J-301	J-302	149.2	PVC	80	715.04	0.47	4.698	5.41	4.7	2.76	0.36
Pipeline_2-33	4	J-285	J-303	149.2	PVC	80	2147.4	1.42	36.004	41.22	36	21.13	2.77
Pipeline_2-11	4	J-304	J-305	69.8	PVC	80	203.94	0.62	18.614	1.81	18.61	10.93	1.43
Pipeline_2-61	6	J-306	J-307	116.4	PVC	80	730.06	0.79	16.361	28.8	16.36	9.6	1.26
Pipeline_2-117	6	J-308	J-309	149.2	PVC	80	2.48	0	0	0	0	0	0
Pipeline_2-44	7	J-310	J-311	102.6	PVC	80	377.7	0.53	8.927	9.05	8.93	5.24	0.69
Pipeline_2-32	9	J-312	J-313	149.2	PVC	80	1867.19	1.24	27.79	31.82	27.79	16.31	2.14

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-123	9	J-312	J-314	250	AC	60	3.57	0	0	0	0	0	0
Pipeline_2-36	10	J-303	J-315	102.6	PVC	80	2026.91	2.84	200.469	445.94	200.47	117.67	15.44
Pipeline_2-100	15	J-316	J-317	102.6	PVC	80	857.15	1.2	40.721	56.17	40.72	23.9	3.14
Pipeline_2-133	23	J-318	J-302	102.6	PVC	80	287.64	0.4	5.39	12.16	5.39	3.16	0.42
Pipeline_2-79	23	J-319	J-291	69.8	PVC	80	10.25	0.03	0.073	0.06	0.07	0.04	0.01
Pipeline_2-18	24	J-300	J-320	102.6	PVC	80	210.81	0.3	3.031	6.74	3.03	1.78	0.23
Pipeline_2-27	24	J-321	J-322	149.2	PVC	80	208.41	0.14	0.479	0.55	0.48	0.28	0.04
Pipeline_2-78	25	J-323	J-324	69.8	PVC	80	9.93	0.03	0.069	0.06	0.07	0.04	0.01

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-17	25	J-320	J-325	102.6	PVC	80	167.62	0.23	1.983	4.41	1.98	1.16	0.15
Pipeline_2-21	25	J-326	J-299	102.6	PVC	80	209.55	0.29	2.998	8.21	3	1.76	0.23
Pipeline_2-29	189	J-301	J-318	102.6	PVC	80	97.54	0.14	0.727	1.55	0.73	0.43	0.06
Pipeline_2-26	26	J-322	J-327	149.2	PVC	80	138.56	0.09	0.225	0.26	0.23	0.13	0.02
Pipeline_2-138	26	J-328	J-304	102.6	PVC	80	592.26	0.83	20.534	21.81	20.53	12.05	1.58
Pipeline_2-146	27	J-329	J-330	69.8	PVC	80	10.65	0.03	0.079	0.07	0.08	0.05	0.01
Pipeline_2-121	28	J-331	J-332	149.2	PVC	80	1078.35	0.71	10.054	11.51	10.05	5.9	0.77
Pipeline_2-28	28	J-318	J-321	149.2	PVC	80	288.7	0.19	0.876	1	0.88	0.51	0.07

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-92	29	J-325	J-333	69.8	PVC	80	11.73	0.04	0.094	0.08	0.09	0.06	0.01
Pipeline_2-91	29	J-334	J-335	69.8	PVC	80	11.78	0.04	0.095	0.08	0.1	0.06	0.01
Pipeline_2-93	29	J-320	J-336	69.8	PVC	80	11.78	0.04	0.095	0.08	0.1	0.06	0.01
Pipeline_2-12	30	J-337	J-328	102.6	PVC	80	666.97	0.93	25.588	30	25.59	15.02	1.97
Pipeline_2-65	33	J-338	J-339	200	AC	60	216.24	0.08	0.21	0.05	0.21	0.12	0.02
Pipeline_2-16	33	J-325	J-334	102.6	PVC	80	120.66	0.17	1.078	2.4	1.08	0.63	0.08
Pipeline_2-14	33	J-315	J-340	102.6	PVC	80	1435.69	2.01	105.844	197.89	105.84	62.13	8.15
Pipeline_2-90	34	J-341	J-342	69.8	PVC	80	13.61	0.04	0.124	0.1	0.12	0.07	0.01

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-110	35	J-341	J-343	102.6	PVC	80	13.92	0.02	0.02	0.04	0.02	0.01	0
Pipeline_2-94	35	J-344	J-300	69.8	PVC	80	76.45	0.23	3.024	1.21	3.02	1.78	0.23
Pipeline_2-31	35	J-313	J-331	149.2	PVC	80	1416.3	0.94	16.657	19.7	16.66	9.78	1.28
Pipeline_2-15	36	J-334	J-341	102.6	PVC	80	69.4	0.1	0.387	0.86	0.39	0.23	0.03
Pipeline_2-8	36	J-345	J-346	69.8	PVC	80	90.03	0.27	4.095	0.59	4.1	2.4	0.32
Pipeline_2-98	38	J-346	J-347	69.8	PVC	80	12.16	0.04	0.1	1.98	0.1	0.06	0.01
Pipeline_2-84	42	J-348	J-349	69.8	PVC	80	144.12	0.44	9.787	17.14	9.79	5.75	0.75
Pipeline_2-67	42	J-350	J-351	200	AC	60	514.41	0.19	1.043	1.8	1.04	0.61	0.08

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-122	42	J-352	J-353	200	AC	60	3564.47	1.31	37.623	44.43	37.62	22.08	2.9
Pipeline_2-51	43	J-354	J-355	102.6	PVC	80	1057.16	1.48	60.048	76.86	60.05	35.25	4.62
Pipeline_2-49	42	J-356	J-357	102.6	PVC	80	674.86	0.94	26.151	36.35	26.15	15.35	2.01
Pipeline_2-58	43	J-358	J-359	69.8	PVC	80	76.33	0.23	3.016	1.33	3.02	1.77	0.23
Pipeline_2-81	43	J-306	J-310	69.8	PVC	80	66.27	0.2	2.322	6.57	2.32	1.36	0.18
Pipeline_2-55	43	J-360	J-361	116.4	PVC	80	1664.18	1.81	75.248	90.75	75.25	44.17	5.79
Pipeline_2-96	43	J-326	J-362	69.8	PVC	80	17.44	0.05	0.196	0.16	0.2	0.12	0.02
Pipeline_2-132	130	J-332	J-363	102.6	PVC	80	171.79	0.24	2.075	2.62	2.08	1.22	0.16

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-120	44	J-332	J-363	149.2	PVC	80	825.52	0.55	6.13	7.75	6.13	3.6	0.47
Pipeline_2-60	44	J-307	J-364	116.4	PVC	80	827.63	0.9	20.638	34.9	20.64	12.11	1.59
Pipeline_2-85	46	J-365	J-366	69.8	PVC	80	18.42	0.06	0.217	0.18	0.22	0.13	0.02
Pipeline_2-97	46	J-309	J-367	69.8	PVC	80	18.43	0.06	0.217	0.18	0.22	0.13	0.02
Pipeline_2-4	47	J-368	J-369	69.8	PVC	80	40.79	0.12	0.945	0.81	0.95	0.55	0.07
Pipeline_2-145	46	J-319	J-348	69.8	PVC	80	71.51	0.22	2.673	5.04	2.67	1.57	0.21
Pipeline_2-30	47	J-363	J-301	149.2	PVC	80	908.67	0.6	7.322	8.38	7.32	4.3	0.56
Pipeline_2-39	47	J-370	J-371	69.8	PVC	80	88.86	0.27	3.997	8.97	4	2.35	0.31

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-150	63	J-372	J-373	69.8	PVC	80	25.36	0.08	0.392	0.32	0.39	0.23	0.03
Pipeline_2-13	47	J-374	J-316	102.6	PVC	80	1221.56	1.71	78.479	142.08	78.48	46.07	6.04
Pipeline_2-99	48	J-337	J-375	102.6	PVC	80	19.26	0.03	0.036	0.08	0.04	0.02	0
Pipeline_2-143	48	J-376	J-377	69.8	PVC	80	19.28	0.06	0.236	0.2	0.24	0.14	0.02
Pipeline_2-152	65	J-378	J-379	69.8	PVC	80	55.87	0.17	1.692	1.55	1.69	0.99	0.13
Pipeline_2-106	48	J-358	J-380	102.6	PVC	80	19.43	0.03	0.037	0.08	0.04	0.02	0
Pipeline_2-95	50	J-299	J-381	69.8	PVC	80	20	0.06	0.253	0.21	0.25	0.15	0.02
Pipeline_2-136	50	J-355	J-352	102.6	PVC	80	719.79	1.01	29.467	36.68	29.47	17.3	2.27

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-101	51	J-340	J-374	102.6	PVC	80	1312.61	1.84	89.655	164.77	89.66	52.63	6.9
Pipeline_2-130	51	J-361	J-382	116.4	PVC	80	2164.97	2.35	122.487	128.61	122.49	71.9	9.43
Pipeline_2-118	51	J-327	J-309	149.2	PVC	80	62.36	0.04	0.051	0.06	0.05	0.03	0
Pipeline_2-35	51	J-353	J-285	149.2	PVC	80	2566.27	1.7	50.083	61.69	50.08	29.4	3.86
Pipeline_2-86	52	J-365	J-383	69.8	PVC	80	57.56	0.17	1.788	1.48	1.79	1.05	0.14
Pipeline_2-5	52	J-369	J-378	69.8	PVC	80	56.89	0.17	1.749	6.87	1.75	1.03	0.14
Pipeline_2-42	53	J-384	J-370	69.8	PVC	80	145.7	0.44	9.987	5.26	9.99	5.86	0.77
Pipeline_2-153	66	J-385	J-369	69.8	PVC	80	163.83	0.5	12.408	20.75	12.41	7.28	0.96

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-10	56	J-304	J-329	69.8	PVC	80	353.57	1.07	51.577	31.2	51.58	30.27	3.97
Pipeline_2-128	56	J-386	J-387	149.2	PVC	80	634.63	0.42	3.766	4.31	3.77	2.21	0.29
Pipeline_2-24	56	J-302	J-287	102.6	PVC	80	394.44	0.55	9.673	21.52	9.67	5.68	0.75
Pipeline_2-87	56	J-327	J-388	69.8	PVC	80	22.6	0.07	0.317	0.26	0.32	0.19	0.02
Pipeline_2-47	56	J-360	J-290	102.6	PVC	80	311.09	0.44	6.232	14.38	6.23	3.66	0.48
Pipeline_2-69	56	J-389	J-390	200	AC	60	924.58	0.34	3.091	3.85	3.09	1.81	0.24
Pipeline_2-104	58	J-290	J-354	102.6	PVC	80	187.8	0.26	2.447	5.78	2.45	1.44	0.19
Pipeline_2-62	59	J-338	J-306	116.4	PVC	80	620.45	0.67	12.104	20.99	12.1	7.11	0.93

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-9	59	J-323	J-345	69.8	PVC	80	183.66	0.56	15.332	6.55	15.33	9	1.18
Pipeline_2-155	82	J-378	J-391	69.8	PVC	80	78.92	0.24	3.208	0.03	3.21	1.88	0.25
Pipeline_2-40	60	J-389	J-349	102.6	PVC	80	37.13	0.05	0.122	1.99	0.12	0.07	0.01
Pipeline_2-45	61	J-339	J-310	102.6	PVC	80	399.58	0.56	9.907	15.58	9.91	5.82	0.76
Pipeline_2-43	61	J-351	J-384	102.6	PVC	80	621.14	0.87	22.428	27.52	22.43	13.16	1.73
Pipeline_2-72	62	J-392	J-393	149.2	PVC	80	365.31	0.24	1.354	1.55	1.35	0.8	0.1
Pipeline_2-88	62	J-322	J-394	69.8	PVC	80	24.85	0.08	0.378	0.31	0.38	0.22	0.03
Pipeline_2-50	64	J-357	J-354	102.6	PVC	80	1178.7	1.65	73.456	101.63	73.46	43.12	5.66

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-75	64	J-374	J-395	69.8	PVC	80	25.88	0.08	0.407	0.34	0.41	0.24	0.03
Pipeline_2-73	65	J-328	J-396	69.8	PVC	80	26.02	0.08	0.411	0.34	0.41	0.24	0.03
Pipeline_2-46	65	J-350	J-356	102.6	PVC	80	508.81	0.71	15.5	19.38	15.5	9.1	1.19
Pipeline_2-154	66	J-397	J-317	69.8	PVC	80	26.55	0.08	0.427	0.35	0.43	0.25	0.03
Pipeline_2-149	68	J-373	J-305	69.8	PVC	80	383.84	1.16	60.052	33.55	60.05	35.25	4.62
Pipeline_2-63	69	J-398	J-386	149.2	PVC	80	468.48	0.31	2.147	2.46	2.15	1.26	0.17
Pipeline_2-77	69	J-345	J-399	69.8	PVC	80	27.74	0.08	0.463	0.38	0.46	0.27	0.04
Pipeline_2-151	71	J-379	J-347	69.8	PVC	80	29.96	0.09	0.534	3.16	0.53	0.31	0.04

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-74	72	J-400	J-401	69.8	PVC	80	28.78	0.09	0.496	0.41	0.5	0.29	0.04
Pipeline_2-53	72	J-402	J-382	200	AC	60	6622.21	2.44	118.483	147.38	118.48	69.55	9.12
Pipeline_2-57	73	J-359	J-376	69.8	PVC	80	146.48	0.44	10.086	8.35	10.09	5.92	0.78
Pipeline_2-22	72	J-331	J-326	102.6	PVC	80	283.61	0.4	5.251	13.65	5.25	3.08	0.4
Pipeline_2-89	74	J-321	J-403	69.8	PVC	80	29.66	0.09	0.524	0.43	0.52	0.31	0.04
Pipeline_2-137	100	J-317	J-337	102.6	PVC	80	757.84	1.06	32.416	41.57	32.42	19.03	2.5
Pipeline_2-6	79	J-391	J-373	69.8	PVC	80	274.07	0.83	32.18	14.95	32.18	18.89	2.48
Pipeline_2-71	78	J-404	J-392	200	AC	60	490.05	0.18	0.954	1.19	0.95	0.56	0.07

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-1	80	J-368	J-379	69.8	PVC	80	60.62	0.18	1.968	5.28	1.97	1.16	0.15
Pipeline_2-107	82	J-349	J-294	102.6	PVC	80	33.03	0.05	0.098	0.22	0.1	0.06	0.01
Pipeline_2-126	85	J-392	J-405	200	AC	60	34.17	0.01	0.007	0.01	0.01	0	0
Pipeline_2-2	123	J-385	J-368	69.8	PVC	80	120.1	0.36	6.982	11.38	6.98	4.1	0.54
Pipeline_2-148	90	J-346	J-406	69.8	PVC	80	36.2	0.11	0.757	0.63	0.76	0.45	0.06
Pipeline_2-7	130	J-347	J-391	69.8	PVC	80	78.23	0.24	3.156	2.51	3.16	1.85	0.24
Pipeline_2-125	111	T-2	J-402	300	AC	60	8704	1.43	27.276	33.93	27.28	16.01	2.1
Pipeline_2-82	96	J-290	J-408	69.8	PVC	80	38.63	0.12	0.854	0.71	0.85	0.5	0.07

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-19	98	J-313	J-344	102.6	PVC	80	393.9	0.55	9.648	19.02	9.65	5.66	0.74
Pipeline_2-83	98	J-376	J-409	69.8	PVC	80	39.28	0.12	0.881	0.73	0.88	0.52	0.07
Pipeline_2-147	103	J-329	J-323	69.8	PVC	80	268.5	0.81	30.978	16.76	30.98	18.18	2.39
Pipeline_2-70	106	J-390	J-404	200	AC	60	767.59	0.28	2.19	2.72	2.19	1.29	0.17
Pipeline_2-54	107	J-402	J-312	250	AC	60	1920.76	0.45	4.037	5.02	4.04	2.37	0.31
Pipeline_2-80	108	J-311	J-356	69.8	PVC	80	79.43	0.24	3.247	1.81	3.25	1.91	0.25
Pipeline_2-41	108	J-370	J-348	69.8	PVC	80	151.12	0.46	10.685	12.6	10.69	6.27	0.82
Pipeline_2-52	108	J-382	J-352	200	AC	60	4364.62	1.61	54.744	59.89	54.74	32.13	4.22

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-37	110	J-371	J-319	69.8	PVC	80	153.89	0.47	11.05	14.05	11.05	6.49	0.85
Pipeline_2-103	110	J-361	J-355	102.6	PVC	80	418.87	0.59	10.811	16.33	10.81	6.35	0.83
Pipeline_2-34	113	J-371	J-285	69.8	PVC	80	351.16	1.06	50.927	68.02	50.93	29.89	3.92
Pipeline_2-142	144	J-386	J-410	69.8	PVC	80	57.93	0.18	1.81	1.5	1.81	1.06	0.14
Pipeline_2-76	111	J-340	J-411	69.8	PVC	80	44.64	0.14	1.117	0.93	1.12	0.66	0.09
Pipeline_2-140	163	J-305	J-316	69.8	PVC	80	274.24	0.83	32.218	39.85	32.22	18.91	2.48
Pipeline_2-108	114	J-390	J-298	102.6	PVC	80	45.82	0.06	0.18	0.4	0.18	0.11	0.01
Pipeline_2-102	145	J-311	J-357	102.6	PVC	80	402.56	0.56	10.045	11.96	10.05	5.9	0.77

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-66	121	J-339	J-350	200	AC	60	97.27	0.04	0.048	0.58	0.05	0.03	0
Pipeline_2-59	122	J-307	J-358	102.6	PVC	80	28.49	0.04	0.074	0.48	0.07	0.04	0.01
Pipeline_2-56	124	J-364	J-360	116.4	PVC	80	1263.01	1.37	45.148	60.02	45.15	26.5	3.48
Pipeline_2-105	122	J-359	J-364	102.6	PVC	80	318.42	0.45	6.507	12.67	6.51	3.82	0.5
Pipeline_2-115	143	J-303	J-296	149.2	PVC	80	57.52	0.04	0.044	0.05	0.04	0.03	0
Pipeline_2-134	154	J-288	J-383	102.6	PVC	80	140.06	0.2	1.422	3.16	1.42	0.83	0.11
Pipeline_2-129	168	J-393	J-412	149.2	PVC	80	67.36	0.04	0.059	0.07	0.06	0.04	0.01
Pipeline_2-64	178	J-387	J-338	200	AC	60	728.61	0.27	1.988	2.47	1.99	1.17	0.15

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-135	184	J-384	J-353	102.6	PVC	80	886.69	1.24	43.358	59.71	43.36	25.45	3.34
Pipeline_2-131	257	J-344	J-400	102.6	PVC	80	160.83	0.23	1.836	4.09	1.84	1.08	0.14
Pipeline_2-68	199	J-351	J-389	200	AC	60	1014.36	0.37	3.67	3.98	3.67	2.15	0.28
Pipeline_2-141	250	J-398	J-413	69.8	PVC	80	100.37	0.3	5.008	4.15	5.01	2.94	0.39
Pipeline_2-109	212	J-287	J-414	102.6	PVC	80	85	0.12	0.564	1.25	0.56	0.33	0.04
Pipeline_2-116	253	J-415	J-404	149.2	PVC	80	101.69	0.07	0.127	0.15	0.13	0.07	0.01
Pipeline_2-139	256	J-393	J-416	102.6	PVC	80	102.82	0.14	0.802	1.78	0.8	0.47	0.06
Pipeline_2-3	267	J-315	J-385	69.8	PVC	80	466.82	1.41	86.285	112.12	86.29	50.65	6.64

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_2-127	299	J-417	J-398	149.2	PVC	80	119.97	0.08	0.172	0.2	0.17	0.1	0.01

Node/ Junction results for Gomti Nagar DMA

Label	Elevation (m)	Demand (m³/day)	Hydraulic Grade (m)	Pressure (kg/cm²)At present condition	Pressure (kg/cm²) 4 Hours Supply	Pressure (kg/cm²) 6 Hours Supply	Pressure (kg/cm²) 8 Hours Supply	Pressure (kg/cm²) 24 Hours Supply
J-285	116.1	16.96	129.46	-0.03	-1.16	-0.03	0.86	1.96
J-286	116.1	0	129.46	-0.03	-1.16	-0.03	0.86	1.96
J-287	113.4	26.94	130.13	1.82	0.94	1.82	2.06	2.35
J-288	113.4	15.49	130.13	1.82	0.94	1.82	2.06	2.35
J-289	115.8	0.01	129.47	0.02	-1.1	0.02	0.9	1.99
J-290	115.8	21.19	129.47	0.02	-1.1	0.02	0.9	1.99
J-291	115.7	2.46	129.12	-0.69	-2.04	-0.69	0.49	1.95
J-292	115.7	0.1	129.12	-0.69	-2.04	-0.69	0.49	1.95
J-294	115.9	8.27	129.09	-0.76	-2.15	-0.76	0.44	1.92
J-296	115.9	14.41	129.45	-0.03	-1.15	-0.03	0.87	1.98
J-298	115.4	11.48	129.08	-0.73	-2.14	-0.73	0.48	1.97
J-299	114.3	7.74	130.16	1.83	0.96	1.83	2.03	2.27
J-300	114.3	6.08	130.16	1.83	0.96	1.83	2.03	2.27
J-301	114.1	24.07	130.17	1.81	1	1.81	2.02	2.29
J-302	114.2	8.25	130.17	1.8	0.98	1.8	2.01	2.28
J-303	116.2	15.77	129.45	-0.06	-1.18	-0.06	0.84	1.95
J-304	116.7	8.7	128.28	-1.99	-4.47	-1.99	-0.31	1.75
J-305	116.6	23.63	128.28	-1.99	-4.46	-1.99	-0.31	1.76
J-306	113.8	10.85	129.16	-0.41	-1.74	-0.41	0.73	2.14
J-307	113.9	17.3	129.17	-0.41	-1.73	-0.41	0.73	2.13
J-308	115	0.62	130.16	1.7	0.87	1.7	1.92	2.19
J-309	115	10.38	130.16	1.7	0.87	1.7	1.92	2.19
J-310	114.7	11.12	129.15	-0.51	-1.86	-0.51	0.64	2.05
J-311	114.8	26.12	129.16	-0.51	-1.86	-0.51	0.63	2.04
J-312	113.5	12.52	130.24	2.04	1.26	2.04	2.18	2.36
J-313	113.6	14.27	130.23	2.01	1.22	2.01	2.16	2.35
J-314	113.3	0.9	130.24	2.06	1.28	2.06	2.2	2.38
J-315	116.3	31.16	129.3	-0.26	-1.62	-0.26	0.72	1.92
J-316	117	22.58	128.51	-1.5	-3.85	-1.5	-0.04	1.76
J-317	117	18.22	128.48	-1.56	-3.93	-1.56	-0.08	1.76
J-318	114.5	24.17	130.16	1.75	0.93	1.75	1.97	2.24

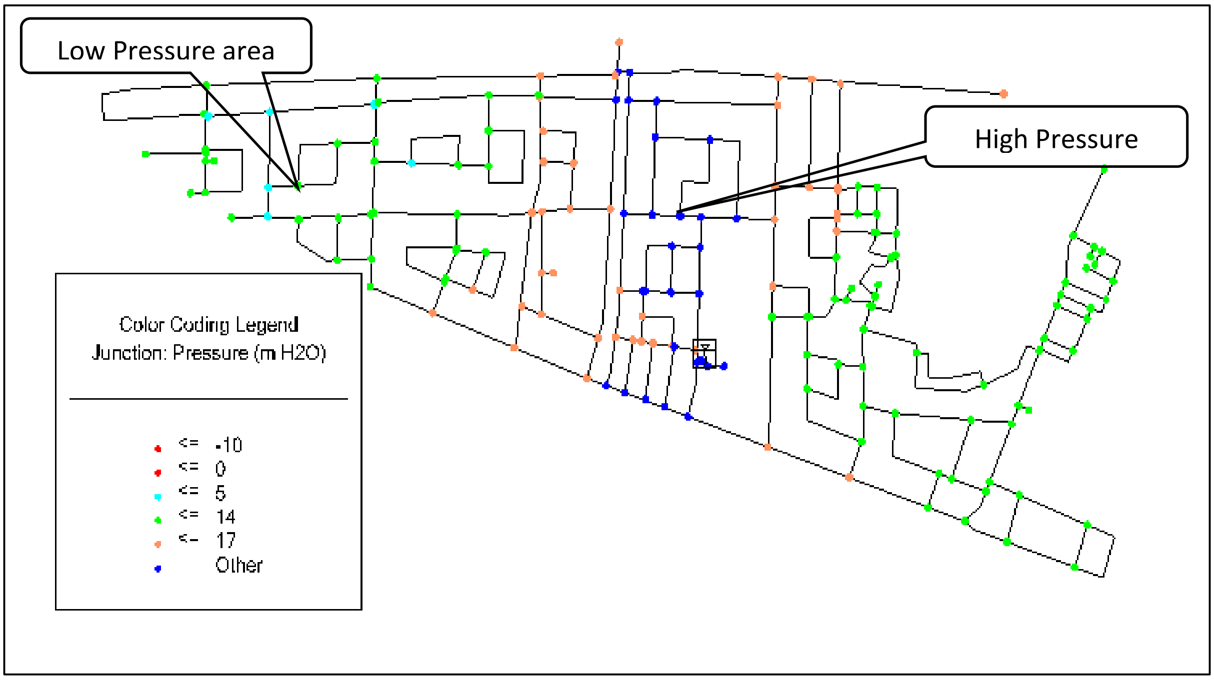
Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm^2)At present condition	Pressure (kg/cm^2) 4 Hours Supply	Pressure (kg/cm^2) 6 Hours Supply	Pressure (kg/cm^2) 8 Hours Supply	Pressure (kg/cm^2) 24 Hours Supply
J-319	115.5	18.07	129.12	-0.67	-2.02	-0.67	0.51	1.97
J-320	114.1	7.87	130.16	1.84	0.96	1.84	2.04	2.29
J-321	114.9	12.68	130.16	1.71	0.88	1.71	1.93	2.2
J-322	115	11.27	130.16	1.7	0.87	1.7	1.92	2.19
J-323	117.9	18.76	128.15	-2.72	-4.93	-2.72	-0.79	1.59
J-324	118.1	2.49	128.15	-2.74	-4.95	-2.74	-0.81	1.57
J-325	114.2	8.83	130.15	1.83	0.94	1.83	2.03	2.28
J-326	114.6	14.18	130.17	1.81	0.95	1.81	2	2.24
J-327	115	13.43	130.16	1.7	0.87	1.7	1.92	2.19
J-328	116.8	12.19	128.3	-1.95	-4.42	-1.95	-0.29	1.75
J-329	117.5	18.64	128.21	-2.36	-4.72	-2.36	-0.56	1.65
J-330	117.5	2.67	128.21	-2.36	-4.72	-2.36	-0.56	1.65
J-331	113.8	13.61	130.21	1.93	1.13	1.93	2.1	2.32
J-332	114.1	20.3	130.2	1.87	1.07	1.87	2.06	2.29
J-333	114.8	2.94	130.15	1.77	0.88	1.77	1.97	2.22
J-334	114.8	9.89	130.15	1.77	0.88	1.77	1.97	2.22
J-335	115.5	2.95	130.15	1.7	0.81	1.7	1.9	2.15
J-336	114.2	2.95	130.16	1.83	0.95	1.83	2.03	2.28
J-337	116.9	17.93	128.33	-1.88	-4.34	-1.88	-0.26	1.74
J-338	112.9	27.07	129.12	-0.39	-1.77	-0.39	0.78	2.23
J-339	113.3	21.56	129.12	-0.43	-1.81	-0.43	0.74	2.19
J-340	116.6	19.65	129.06	-0.64	-2.31	-0.64	0.48	1.87
J-341	115.4	10.49	130.15	1.7	0.81	1.7	1.91	2.16
J-342	116.1	3.41	130.15	1.63	0.74	1.63	1.84	2.09
J-343	115.7	3.49	130.15	1.67	0.78	1.67	1.88	2.13
J-344	114.3	39.23	130.17	1.84	0.96	1.84	2.03	2.27
J-345	117.7	16.5	128.14	-2.79	-4.95	-2.79	-0.82	1.6
J-346	118	16.53	128.14	-2.83	-4.98	-2.83	-0.86	1.57
J-347	117.9	24.05	128.14	-2.82	-4.97	-2.82	-0.85	1.58
J-348	114.9	19.66	129.12	-0.62	-1.98	-0.62	0.56	2.02
J-349	115.6	18.53	129.09	-0.73	-2.12	-0.73	0.47	1.95
J-350	113.3	22.96	129.12	-0.43	-1.82	-0.43	0.74	2.19
J-351	113.4	30.35	129.11	-0.44	-1.84	-0.44	0.73	2.18

Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm^2)At present condition	Pressure (kg/cm^2) 4 Hours Supply	Pressure (kg/cm^2) 6 Hours Supply	Pressure (kg/cm^2) 8 Hours Supply	Pressure (kg/cm^2) 24 Hours Supply
J-352	115.1	20.13	129.64	0.48	-0.55	0.48	1.2	2.09
J-353	115.6	27.93	129.57	0.27	-0.79	0.27	1.06	2.03
J-354	115.2	16.6	129.46	0.07	-1.08	0.07	0.95	2.05
J-355	115.3	20.41	129.58	0.31	-0.76	0.31	1.1	2.06
J-356	114.3	21.7	129.16	-0.42	-1.79	-0.42	0.7	2.1
J-357	114.6	25.37	129.22	-0.34	-1.67	-0.34	0.74	2.07
J-358	113.5	21.39	129.17	-0.37	-1.7	-0.37	0.77	2.17
J-359	113.9	23.95	129.17	-0.39	-1.73	-0.39	0.74	2.13
J-360	115.8	22.56	129.5	0.06	-1.02	0.06	0.92	1.99
J-361	115.1	20.52	129.64	0.45	-0.56	0.45	1.18	2.09
J-362	114.2	4.37	130.17	1.85	0.99	1.85	2.04	2.28
J-363	114	22.2	130.18	1.85	1.04	1.85	2.05	2.3
J-364	114.6	29.29	129.23	-0.38	-1.65	-0.38	0.71	2.07
J-365	115	9.8	130.11	1.63	0.73	1.63	1.88	2.19
J-366	114.6	4.61	130.11	1.67	0.77	1.67	1.92	2.23
J-367	114.6	4.62	130.16	1.74	0.91	1.74	1.96	2.23
J-368	116.6	25.11	128.16	-2.67	-4.77	-2.67	-0.71	1.71
J-369	115.4	16.57	128.16	-2.55	-4.65	-2.55	-0.59	1.83
J-370	113.9	20.9	129.16	-0.41	-1.75	-0.41	0.73	2.13
J-371	114.5	27.15	129.18	-0.45	-1.76	-0.45	0.68	2.07
J-372	116.9	6.35	128.19	-2.43	-4.72	-2.43	-0.58	1.7
J-373	116.9	21.14	128.19	-2.43	-4.72	-2.43	-0.58	1.7
J-374	116.9	16.32	128.75	-1.12	-3.17	-1.12	0.18	1.8
J-375	116.2	4.82	128.33	-1.81	-4.27	-1.81	-0.19	1.81
J-376	115	22.02	129.15	-0.58	-1.9	-0.58	0.58	2.02
J-377	114.2	4.83	129.15	-0.5	-1.82	-0.5	0.66	2.1
J-378	116.7	20.02	128.15	-2.69	-4.81	-2.69	-0.72	1.7
J-379	117.7	21.67	128.15	-2.8	-4.92	-2.8	-0.83	1.6
J-380	114.5	4.87	129.17	-0.47	-1.8	-0.47	0.67	2.07
J-381	114	5.01	130.16	1.86	0.99	1.86	2.06	2.3
J-382	114.3	23.2	129.88	1.15	0.17	1.15	1.63	2.22
J-383	114.8	20.67	130.11	1.66	0.75	1.66	1.91	2.21
J-384	114	30.02	129.17	-0.36	-1.73	-0.36	0.75	2.13

Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm²)At present condition	Pressure (kg/cm²) 4 Hours Supply	Pressure (kg/cm²) 6 Hours Supply	Pressure (kg/cm²) 8 Hours Supply	Pressure (kg/cm²) 24 Hours Supply
J-385	115.1	45.81	128.21	-2.44	-4.48	-2.44	-0.51	1.87
J-386	114.8	27.1	129.09	-0.63	-2.03	-0.63	0.56	2.03
J-387	113.6	23.54	129.1	-0.49	-1.89	-0.49	0.69	2.15
J-388	114.7	5.66	130.16	1.73	0.9	1.73	1.95	2.22
J-389	114.9	31.79	129.09	-0.66	-2.07	-0.66	0.54	2.02
J-390	115.5	27.84	129.08	-0.74	-2.15	-0.74	0.47	1.96
J-391	116.9	29.28	128.15	-2.68	-4.83	-2.68	-0.73	1.68
J-392	115.8	22.69	129.06	-0.8	-2.21	-0.8	0.42	1.93
J-393	115.2	48.87	129.06	-0.75	-2.16	-0.75	0.48	1.99
J-394	114.1	6.22	130.16	1.79	0.96	1.79	2.01	2.28
J-395	117.7	6.48	128.75	-1.21	-3.25	-1.21	0.1	1.72
J-396	117	6.52	128.3	-1.97	-4.44	-1.97	-0.31	1.73
J-397	118.8	6.65	128.48	-1.75	-4.11	-1.75	-0.26	1.58
J-398	113.8	62.15	129.09	-0.55	-1.95	-0.55	0.65	2.13
J-399	117.4	6.95	128.14	-2.76	-4.92	-2.76	-0.79	1.63
J-400	117.5	33.07	130.13	1.48	0.54	1.48	1.69	1.95
J-401	119.9	7.21	130.13	1.23	0.3	1.23	1.44	1.71
J-402	114.2	40.33	130.26	2.01	1.24	2.01	2.14	2.29
J-403	113.4	7.43	130.16	1.86	1.03	1.86	2.08	2.35
J-404	115	44.04	129.07	-0.71	-2.13	-0.71	0.5	2.01
J-405	116.3	8.56	129.06	-0.85	-2.26	-0.85	0.37	1.88
J-406	117.8	9.07	128.13	-2.82	-4.97	-2.82	-0.85	1.59
J-408	115.8	9.67	129.47	0.01	-1.11	0.01	0.9	1.99
J-409	114.8	9.84	129.15	-0.57	-1.89	-0.57	0.6	2.04
J-410	112.9	14.51	129.09	-0.47	-1.86	-0.47	0.73	2.22
J-411	116	11.18	129.05	-0.59	-2.26	-0.59	0.53	1.93
J-412	113.1	16.87	129.06	-0.54	-1.96	-0.54	0.68	2.2
J-413	112.3	25.14	129.05	-0.52	-1.9	-0.52	0.73	2.27
J-414	112.3	21.29	130.12	1.92	1.03	1.92	2.16	2.46
J-415	112	25.47	129.07	-0.42	-1.83	-0.42	0.8	2.31
J-416	117	25.75	129.04	-0.95	-2.39	-0.95	0.28	1.81
J-417	113.2	30.05	129.09	-0.49	-1.89	-0.49	0.71	2.19

Rajajipuram DMA

In case of Rajajipuram DMA, the total flow through this DMA is 1.66 MLD. This demand is applied to that DMA. As the supply for this DMA is for 6.00 hours, the peak factor is 4.



The results of calibration are presented in table below:

Pipe results for Rajajipuram DMA

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-15	0	J-418	J-419	69.8	PVC	80	0	0	0	0	0	0	0
Pipeline_3-232	0	J-420	J-421	69.8	PVC	80	0.01	0	0	0	0	0	0
Pipeline_3-64	0	J-422	J-423	69.8	PVC	80	0.01	0	0	0	0	0	0
Pipeline_3-28	0	J-424	J-425	69.8	PVC	80	0.02	0	0	0	0	0	0
Pipeline_3-26	3	J-426	J-427	69.8	PVC	80	49.43	0.15	1.349	1.12	1.35	0.8	0.1
Pipeline_3-98	3	J-428	J-429	102.6	PVC	80	359.57	0.5	8.149	18.13	8.15	4.79	0.62
Pipeline_3-54	3	J-430	J-431	102.6	PVC	80	167.39	0.23	1.976	4.35	1.98	1.16	0.15

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-74	3	J-432	J-433	69.8	PVC	80	83.27	0.25	3.543	5.67	3.54	2.08	0.27
Pipeline_3-34	3	J-434	J-435	69.8	PVC	80	469.78	1.42	87.299	101.6	87.3	51.26	6.69
Pipeline_3-217	3	J-436	J-437	69.8	PVC	80	149.27	0.45	10.444	7.26	10.44	6.13	0.8
Pipeline_3-8	4	J-438	J-439	69.8	PVC	80	90.87	0.27	4.161	1.5	4.16	2.46	0.32
Pipeline_3-62	4	J-440	J-441	69.8	PVC	80	19.82	0.06	0.248	0.12	0.25	0.15	0.02
Pipeline_3-9	5	J-442	J-443	69.8	PVC	80	40.19	0.12	0.914	2.3	0.91	0.53	0.07
Pipeline_3-135	5	J-444	J-445	102.6	PVC	80	100.15	0.14	0.764	1.52	0.76	0.45	0.06
Pipeline_3-2	7	J-446	J-447	250	CI	60	6614.6	1.56	39.874	49.6	39.87	23.41	3.06

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-3	11	T-3	J-446	250	CI	60	5768.24	1.36	30.943	38.49	30.94	18.17	2.37
Pipeline_3-56	7	J-449	J-450	102.6	PVC	80	39.95	0.06	0.139	0.16	0.14	0.08	0.01
Pipeline_3-67	9	J-451	J-452	69.8	PVC	80	0.15	0	0	0	0	0	0
Pipeline_3-134	12	J-445	J-453	102.6	PVC	80	58.97	0.08	0.286	0.53	0.29	0.17	0.02
Pipeline_3-1	13	J-446	J-454	150	AC	60	854.73	0.56	10.851	13.5	10.85	6.37	0.83
Pipeline_3-133	13	J-455	J-453	150	AC	60	2.61	0	0	0	0	0	0
Pipeline_3-23	14	J-456	J-457	69.8	PVC	80	22.15	0.07	0.305	1.4	0.31	0.18	0.02
Pipeline_3-86	14	J-458	J-459	69.8	PVC	80	13.15	0.04	0.116	0	0.12	0.07	0.01

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-168	15	J-460	J-459	69.8	PVC	80	2.94	0.01	0.007	0.01	0.01	0	0
Pipeline_3-106	15	J-461	J-462	102.6	PVC	80	578.67	0.81	19.67	34.02	19.67	11.55	1.51
Pipeline_3-68	16	J-436	J-463	69.8	PVC	80	73.75	0.22	2.83	1.96	2.83	1.66	0.22
Pipeline_3-17	16	J-464	J-465	102.6	PVC	80	651.3	0.91	24.486	33.83	24.49	14.38	1.88
Pipeline_3-225	17	J-466	J-467	69.8	PVC	80	61.03	0.18	1.992	3.41	1.99	1.17	0.15
Pipeline_3-181	18	J-454	T-3	150	AC	60	874.76	0.57	11.327	14.09	11.33	6.65	0.87
Pipeline_3-97	17	J-429	J-469	102.6	PVC	80	281.08	0.39	5.164	9.57	5.16	3.03	0.4
Pipeline_3-175	17	J-470	J-471	150	AC	60	3.41	0	0.001	0	0	0	0

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-25	17	J-457	J-472	69.8	PVC	80	54.85	0.17	1.636	0.89	1.64	0.96	0.13
Pipeline_3-93	17	J-473	J-474	102.6	PVC	80	177.26	0.25	2.199	3.5	2.2	1.29	0.17
Pipeline_3-157	18	J-463	J-475	69.8	PVC	80	3.49	0.01	0.01	0.01	0.01	0.01	0
Pipeline_3-161	18	J-476	J-477	69.8	PVC	80	84.76	0.26	3.662	5.34	3.66	2.15	0.28
Pipeline_3-174	18	J-478	J-479	150	AC	60	3.67	0	0.001	0	0	0	0
Pipeline_3-198	19	J-480	J-476	69.8	PVC	80	3.72	0.01	0.011	0.01	0.01	0.01	0
Pipeline_3-65	19	J-450	J-423	102.6	PVC	80	14.48	0.02	0.021	0.03	0.02	0.01	0
Pipeline_3-46	19	J-481	J-482	150	AC	60	395.17	0.26	2.6	2.14	2.6	1.53	0.2

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-90	19	J-474	J-483	102.6	PVC	80	149.43	0.21	1.603	2.88	1.6	0.94	0.12
Pipeline_3-103	21	J-484	J-485	69.8	PVC	80	164.73	0.5	12.535	15.25	12.54	7.36	0.96
Pipeline_3-199	23	J-458	J-486	69.8	PVC	80	4.54	0.01	0.016	0.01	0.02	0.01	0
Pipeline_3-200	23	J-487	J-488	69.8	PVC	80	4.63	0.01	0.017	0.01	0.02	0.01	0
Pipeline_3-187	26	J-454	J-489	150	AC	60	5.09	0	0.001	0	0	0	0
Pipeline_3-88	38	J-467	J-490	69.8	PVC	80	50.3	0.15	1.393	1.93	1.39	0.82	0.11
Pipeline_3-61	27	J-441	J-491	69.8	PVC	80	2.28	0.01	0.003	0.05	0	0	0
Pipeline_3-24	28	J-492	J-456	69.8	PVC	80	184.97	0.56	15.537	19.94	15.54	9.12	1.19

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-234	29	J-493	J-494	102.6	PVC	80	226.06	0.32	3.45	5.97	3.45	2.03	0.27
Pipeline_3-100	29	J-495	J-471	102.6	PVC	80	398.51	0.56	9.858	19.1	9.86	5.79	0.76
Pipeline_3-89	29	J-490	J-496	69.8	PVC	80	47.65	0.14	1.26	1.65	1.26	0.74	0.1
Pipeline_3-60	30	J-497	J-498	69.8	PVC	80	30.41	0.09	0.549	0.64	0.55	0.32	0.04
Pipeline_3-159	31	J-499	J-491	69.8	PVC	80	27.95	0.08	0.469	0.52	0.47	0.28	0.04
Pipeline_3-20	31	J-500	J-501	102.6	PVC	80	795.6	1.11	35.472	84.25	35.47	20.83	2.72
Pipeline_3-69	31	J-502	J-451	69.8	PVC	80	18.45	0.06	0.217	0.09	0.22	0.13	0.02
Pipeline_3-116	31	J-503	J-504	150	AC	60	2133.5	1.4	59.049	75.26	59.05	34.67	4.53

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-160	31	J-441	J-502	69.8	PVC	80	9.61	0.03	0.064	0.07	0.06	0.04	0.01
Pipeline_3-27	32	J-472	J-426	69.8	PVC	80	12.29	0.04	0.103	0	0.1	0.06	0.01
Pipeline_3-58	32	J-449	J-499	69.8	PVC	80	42.83	0.13	1.034	0.84	1.03	0.61	0.08
Pipeline_3-117	32	J-504	J-505	150	AC	60	2292.23	1.5	67.442	89.32	67.44	39.6	5.17
Pipeline_3-136	33	J-506	J-507	69.8	PVC	80	6.47	0.02	0.031	0.03	0.03	0.02	0
Pipeline_3-43	33	J-508	J-509	102.6	PVC	80	878.84	1.23	42.649	69.45	42.65	25.04	3.27
Pipeline_3-59	33	J-431	J-497	69.8	PVC	80	56.3	0.17	1.716	2.01	1.72	1.01	0.13
Pipeline_3-57	34	J-431	J-449	102.6	PVC	80	97.26	0.14	0.724	1.25	0.72	0.43	0.06

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-144	34	J-427	J-510	69.8	PVC	80	6.84	0.02	0.035	0.03	0.04	0.02	0
Pipeline_3-196	36	J-511	J-437	102.6	PVC	80	100.94	0.14	0.775	0.6	0.78	0.46	0.06
Pipeline_3-29	37	J-434	J-425	69.8	PVC	80	184.94	0.56	15.531	17.54	15.53	9.12	1.19
Pipeline_3-141	37	J-425	J-457	69.8	PVC	80	90.51	0.27	4.135	5.18	4.14	2.43	0.32
Pipeline_3-226	37	J-459	J-512	69.8	PVC	80	29.11	0.09	0.506	0.13	0.51	0.3	0.04
Pipeline_3-33	37	J-513	J-434	69.8	PVC	80	269.49	0.82	31.19	37.7	31.19	18.31	2.39
Pipeline_3-170	38	J-423	J-514	102.6	PVC	80	44.92	0.06	0.173	0.5	0.17	0.1	0.01
Pipeline_3-218	39	J-491	J-498	69.8	PVC	80	6.38	0.02	0.029	0.01	0.03	0.02	0

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-71	44	J-437	J-476	69.8	PVC	80	64.9	0.2	2.233	3.76	2.23	1.31	0.17
Pipeline_3-137	39	J-515	J-516	69.8	PVC	80	99.18	0.3	4.898	6.34	4.9	2.88	0.38
Pipeline_3-158	40	J-499	J-497	69.8	PVC	80	5.48	0.02	0.023	0.07	0.02	0.01	0
Pipeline_3-32	40	J-435	J-517	69.8	PVC	80	315.69	0.95	41.812	48	41.81	24.55	3.21
Pipeline_3-172	40	J-518	J-519	102.6	PVC	80	740.69	1.04	31.071	64.24	31.07	18.24	2.38
Pipeline_3-21	41	J-481	J-520	200	MS	80	365.98	0.13	0.326	0.29	0.33	0.19	0.03
Pipeline_3-48	41	J-521	J-522	102.6	PVC	80	173.63	0.24	2.116	5.04	2.12	1.24	0.16
Pipeline_3-45	41	J-482	J-523	102.6	PVC	80	597.78	0.84	20.89	33.17	20.89	12.27	1.6

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Pipeline_3-130	42	J-524	J-525	69.8	PVC	80	96.31	0.29	4.639	3.84	4.64	2.72	0.36
Pipeline_3-180	361	J-526	J-527	150	AC	60	71.97	0.05	0.111	0.14	0.11	0.07	0.01
Pipeline_3-183	43	J-481	J-528	200	MS	80	8.63	0	0	0	0	0	0
Pipeline_3-6	44	J-438	J-443	69.8	PVC	80	22.68	0.07	0.316	0.03	0.32	0.19	0.03
Pipeline_3-186	44	J-529	J-508	150	AC	60	1303.35	0.85	23.704	28.26	23.7	13.92	1.82
Pipeline_3-143	44	J-517	J-530	69.8	PVC	80	388.56	1.18	61.425	71.11	61.43	36.06	4.71
Pipeline_3-42	44	J-509	J-531	102.6	PVC	80	652.66	0.91	24.581	31.8	24.58	14.43	1.89
Pipeline_3-230	44	J-532	J-529	69.8	PVC	80	184.17	0.56	15.412	15.13	15.41	9.05	1.18

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-16	44	J-465	J-419	102.6	PVC	80	357.17	0.5	8.048	10.71	8.05	4.73	0.62
Pipeline_3-171	44	J-531	J-533	102.6	PVC	80	425.94	0.6	11.152	7.87	11.15	6.55	0.86
Pipeline_3-38	45	J-523	J-534	69.8	PVC	80	93.96	0.28	4.431	6.84	4.43	2.6	0.34
Pipeline_3-73	45	J-535	J-536	102.6	PVC	80	303.74	0.43	5.962	6.26	5.96	3.5	0.46
Pipeline_3-149	45	J-537	J-430	69.8	PVC	80	237.44	0.72	24.671	20.27	24.67	14.49	1.89
Pipeline_3-219	65	J-452	J-440	69.8	PVC	80	8.96	0.03	0.057	0	0.06	0.03	0
Pipeline_3-208	46	J-443	J-538	69.8	PVC	80	44.07	0.13	1.09	1.03	1.09	0.64	0.08
Pipeline_3-173	46	J-453	J-487	102.6	PVC	80	42.28	0.06	0.155	0.26	0.16	0.09	0.01

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Pipeline_3-128	46	J-524	J-539	69.8	PVC	80	261.69	0.79	29.54	24.46	29.54	17.34	2.27
Pipeline_3-153	46	J-496	J-540	69.8	PVC	80	9.16	0.03	0.059	0.05	0.06	0.04	0.01
Pipeline_3-87	62	J-496	J-458	69.8	PVC	80	11.07	0.03	0.085	0.3	0.09	0.05	0.01
Pipeline_3-5	47	J-541	J-438	69.8	PVC	80	49.45	0.15	1.349	0.98	1.35	0.8	0.1
Pipeline_3-124	47	J-542	J-543	69.8	PVC	80	234.71	0.71	24.149	20	24.15	14.18	1.85
Pipeline_3-75	56	J-477	J-432	69.8	PVC	80	211.98	0.64	19.997	23.59	20	11.74	1.53
Pipeline_3-162	48	J-544	J-545	69.8	PVC	80	9.52	0.03	0.064	0.05	0.06	0.04	0.01
Pipeline_3-50	48	J-546	J-547	102.6	PVC	80	379.07	0.53	8.986	18.23	8.99	5.28	0.69

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Pipeline_3-152	48	J-469	J-548	69.8	PVC	80	40.21	0.12	0.921	1.03	0.92	0.54	0.07
Pipeline_3-206	49	J-439	J-549	69.8	PVC	80	150.25	0.45	10.572	3.63	10.57	6.21	0.81
Pipeline_3-10	49	J-550	J-442	69.8	PVC	80	69.23	0.21	2.517	6.32	2.52	1.48	0.19
Pipeline_3-77	50	J-551	J-552	69.8	PVC	80	22.49	0.07	0.314	0.06	0.31	0.18	0.02
Pipeline_3-111	50	J-462	J-553	69.8	PVC	80	245.75	0.74	26.294	21.77	26.29	15.44	2.02
Pipeline_3-101	51	J-554	J-555	69.8	PVC	80	158.51	0.48	11.672	5.67	11.67	6.85	0.9
Pipeline_3-233	56	J-515	J-551	69.8	PVC	80	81.63	0.25	3.415	3.78	3.42	2.01	0.26
Pipeline_3-94	51	J-469	J-473	102.6	PVC	80	217.62	0.3	3.215	5.25	3.22	1.89	0.25

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Pipeline_3-96	66	J-429	J-548	69.8	PVC	80	61.49	0.19	2.021	3.24	2.02	1.19	0.16
Pipeline_3-91	51	J-474	J-467	69.8	PVC	80	10.28	0.03	0.074	0.01	0.07	0.04	0.01
Pipeline_3-95	52	J-548	J-466	69.8	PVC	80	68.6	0.21	2.475	4.28	2.48	1.45	0.19
Pipeline_3-169	52	J-473	J-466	69.8	PVC	80	16.41	0.05	0.175	0.08	0.18	0.1	0.01
Pipeline_3-211	210	J-543	J-556	69.8	PVC	80	55.36	0.17	1.663	1.38	1.66	0.98	0.13
Pipeline_3-210	52	J-556	J-557	69.8	PVC	80	110.93	0.34	6.027	4.99	6.03	3.54	0.46
Pipeline_3-123	52	J-543	J-556	69.8	PVC	80	117.89	0.36	6.746	5.59	6.75	3.96	0.52
Pipeline_3-81	52	J-420	J-554	102.6	PVC	80	459.08	0.64	12.812	19.81	12.81	7.52	0.98

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Pipeline_3-156	52	J-558	J-484	69.8	PVC	80	211.8	0.64	19.966	31.99	19.97	11.72	1.53
Pipeline_3-39	52	J-534	J-559	69.8	PVC	80	257.59	0.78	28.688	38.25	28.69	16.84	2.2
Pipeline_3-207	168	J-442	J-439	69.8	PVC	80	15.33	0.05	0.146	0.04	0.15	0.09	0.01
Pipeline_3-52	53	J-521	J-560	150	AC	60	252.05	0.17	1.131	1.27	1.13	0.66	0.09
Pipeline_3-53	53	J-546	J-537	69.8	PVC	80	198.67	0.6	17.734	16.52	17.73	10.41	1.36
Pipeline_3-205	54	J-561	J-518	69.8	PVC	80	76.07	0.23	2.997	2.48	3	1.76	0.23
Pipeline_3-83	55	J-516	J-511	102.6	PVC	80	337.74	0.47	7.256	14.84	7.26	4.26	0.56
Pipeline_3-107	56	J-562	J-461	102.6	PVC	80	559.99	0.78	18.51	30.99	18.51	10.87	1.42

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Pipeline_3-215	55	J-433	J-536	69.8	PVC	80	242.15	0.73	25.585	23.96	25.59	15.02	1.96
Pipeline_3-78	55	J-433	J-551	69.8	PVC	80	136.23	0.41	8.817	5.53	8.82	5.18	0.68
Pipeline_3-80	56	J-563	J-420	102.6	PVC	80	599.09	0.84	20.975	41.64	20.98	12.32	1.61
Pipeline_3-41	56	J-508	J-564	69.8	PVC	80	398.05	1.2	64.233	82.59	64.23	37.71	4.93
Pipeline_3-214	141	J-514	J-450	69.8	PVC	80	7.8	0.02	0.044	0.13	0.04	0.03	0
Pipeline_3-222	57	J-485	J-461	69.8	PVC	80	44.19	0.13	1.096	1.16	1.1	0.64	0.08
Pipeline_3-201	57	J-525	J-565	69.8	PVC	80	11.36	0.03	0.088	0.07	0.09	0.05	0.01
Pipeline_3-82	57	J-554	J-516	102.6	PVC	80	268.66	0.38	4.75	7.71	4.75	2.79	0.36

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Pipeline_3-7	131	J-538	J-541	69.8	PVC	80	0.25	0	0.003	0	0	0	0
Pipeline_3-164	58	J-538	J-541	69.8	PVC	80	2.82	0.01	0.006	0	0.01	0	0
Pipeline_3-63	59	J-423	J-440	69.8	PVC	80	36.39	0.11	0.765	0.71	0.77	0.45	0.06
Pipeline_3-127	59	J-494	J-566	69.8	PVC	80	345.82	1.05	49.502	40.99	49.5	29.06	3.8
Pipeline_3-202	59	J-567	J-493	69.8	PVC	80	376.95	1.14	58.069	48.08	58.07	34.09	4.45
Pipeline_3-145	60	J-564	J-547	69.8	PVC	80	323.77	0.98	43.815	57.59	43.82	25.73	3.36
Pipeline_3-72	60	J-514	J-477	69.8	PVC	80	100.44	0.3	5.015	5.32	5.02	2.94	0.38
Pipeline_3-220	100	J-452	J-463	69.8	PVC	80	43.83	0.13	1.079	0.66	1.08	0.63	0.08

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Pipeline_3-12	61	J-479	J-506	102.6	PVC	80	361.04	0.51	8.211	12.96	8.21	4.82	0.63
Pipeline_3-176	61	J-558	J-562	150	AC	60	583.3	0.38	5.348	5.07	5.35	3.14	0.41
Pipeline_3-76	101	J-552	J-515	69.8	PVC	80	56.54	0.17	1.73	2.12	1.73	1.02	0.13
Pipeline_3-189	61	J-568	J-505	150	AC	60	1019.91	0.67	15.052	20.51	15.05	8.84	1.15
Pipeline_3-165	61	J-561	J-569	69.8	PVC	80	12.22	0.04	0.101	0.08	0.1	0.06	0.01
Pipeline_3-131	175	J-444	J-487	69.8	PVC	80	10.95	0.03	0.083	0.15	0.08	0.05	0.01
Pipeline_3-192	63	J-419	J-570	102.6	PVC	80	462.59	0.65	12.994	19.69	12.99	7.63	1
Pipeline_3-221	64	J-571	J-495	69.8	PVC	80	133.47	0.4	8.49	12.02	8.49	4.98	0.65

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Pipeline_3-231	90	J-425	J-426	69.8	PVC	80	61.86	0.19	2.043	2.29	2.04	1.2	0.16
Pipeline_3-108	65	J-572	J-573	69.8	PVC	80	15.51	0.05	0.155	0.13	0.16	0.09	0.01
Pipeline_3-150	153	J-573	J-572	69.8	PVC	80	9.9	0.03	0.065	0.06	0.07	0.04	0.01
Pipeline_3-14	66	J-419	J-544	69.8	PVC	80	70.8	0.21	2.624	2.17	2.62	1.54	0.2
Pipeline_3-213	97	J-544	J-574	69.8	PVC	80	19.31	0.06	0.237	0.2	0.24	0.14	0.02
Pipeline_3-37	67	J-530	J-529	150	AC	60	1518.51	0.99	31.457	38.57	31.46	18.47	2.41
Pipeline_3-142	67	J-517	J-532	69.8	PVC	80	42.65	0.13	1.026	1.54	1.03	0.6	0.08
Pipeline_3-154	69	J-483	J-490	69.8	PVC	80	24.39	0.07	0.365	0.24	0.37	0.21	0.03

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Pipeline_3-92	70	J-483	J-512	102.6	PVC	80	93.55	0.13	0.673	1.13	0.67	0.4	0.05
Pipeline_3-30	69	J-513	J-492	102.6	PVC	80	34.58	0.05	0.107	0.25	0.11	0.06	0.01
Pipeline_3-151	71	J-575	J-553	69.8	PVC	80	106.68	0.32	5.606	4.64	5.61	3.29	0.43
Pipeline_3-193	72	J-492	J-504	102.6	PVC	80	185.76	0.26	2.398	8.34	2.4	1.41	0.18
Pipeline_3-216	98	J-432	J-535	69.8	PVC	80	159.93	0.48	11.868	10.88	11.87	6.97	0.91
Pipeline_3-227	75	J-575	J-576	69.8	PVC	80	14.85	0.04	0.145	0.12	0.15	0.09	0.01
Pipeline_3-125	74	J-566	J-542	69.8	PVC	80	172.51	0.52	13.653	11.3	13.65	8.02	1.05
Pipeline_3-212	152	J-542	J-566	69.8	PVC	80	116.62	0.35	6.612	5.48	6.61	3.88	0.51

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Pipeline_3-66	97	J-498	J-502	69.8	PVC	80	3.72	0.01	0.01	0.03	0.01	0.01	0
Pipeline_3-140	78	J-503	J-456	69.8	PVC	80	186.65	0.56	15.799	15.18	15.8	9.28	1.21
Pipeline_3-35	105	J-435	J-532	69.8	PVC	80	183.67	0.56	15.334	17.37	15.33	9	1.18
Pipeline_3-184	81	J-447	J-577	250	CI	60	4628.12	1.09	20.58	24.93	20.58	12.08	1.58
Pipeline_3-139	82	J-472	J-578	69.8	PVC	80	16.41	0.05	0.175	0.15	0.18	0.1	0.01
Pipeline_3-70	114	J-451	J-436	69.8	PVC	80	49.05	0.15	1.33	0.84	1.33	0.78	0.1
Pipeline_3-120	103	J-579	J-561	69.8	PVC	80	20.47	0.06	0.263	0.22	0.26	0.16	0.02
Pipeline_3-99	86	J-471	J-428	102.6	PVC	80	368.78	0.52	8.54	16.35	8.54	5.01	0.66

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Pipeline_3-40	86	J-559	J-580	69.8	PVC	80	121.12	0.37	7.092	10.46	7.09	4.16	0.54
Pipeline_3-126	118	J-539	J-567	69.8	PVC	80	159.25	0.48	11.773	9.75	11.77	6.91	0.9
Pipeline_3-203	119	J-567	J-539	69.8	PVC	80	158.79	0.48	11.71	9.7	11.71	6.88	0.9
Pipeline_3-138	88	J-581	J-427	69.8	PVC	80	17.62	0.05	0.2	0.17	0.2	0.12	0.02
Pipeline_3-13	89	J-465	J-479	102.6	PVC	80	323.86	0.45	6.714	10.14	6.71	3.94	0.52
Pipeline_3-85	98	J-511	J-582	69.8	PVC	80	199.28	0.6	17.835	18.94	17.84	10.47	1.37
Pipeline_3-155	91	J-485	J-571	69.8	PVC	80	86.89	0.26	3.834	5.66	3.83	2.25	0.29
Pipeline_3-105	91	J-462	J-495	102.6	PVC	80	301.75	0.42	5.89	7.81	5.89	3.46	0.45

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Pipeline_3-122	92	J-583	J-493	102.6	PVC	80	186.71	0.26	2.421	7.02	2.42	1.42	0.19
Pipeline_3-132	93	J-527	J-444	102.6	PVC	80	165.56	0.23	1.938	4.31	1.94	1.14	0.15
Pipeline_3-167	95	J-445	J-584	69.8	PVC	80	18.89	0.06	0.227	0.19	0.23	0.13	0.02
Pipeline_3-197	96	J-506	J-568	102.6	PVC	80	405.25	0.57	10.169	16.71	10.17	5.97	0.78
Pipeline_3-51	97	J-547	J-535	102.6	PVC	80	96.13	0.13	0.708	0.04	0.71	0.42	0.05
Pipeline_3-4	97	J-585	J-586	69.8	PVC	80	19.39	0.06	0.238	0.2	0.24	0.14	0.02
Pipeline_3-36	100	J-447	J-530	150	AC	60	1949.16	1.28	49.95	66.04	49.95	29.33	3.83
Pipeline_3-223	115	J-587	J-428	69.8	PVC	80	31.39	0.09	0.582	1.6	0.58	0.34	0.05

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-188	105	J-550	J-519	150	AC	60	769.65	0.5	8.936	10.36	8.94	5.25	0.69
Pipeline_3-115	105	J-577	J-503	150	AC	60	2362.79	1.55	71.338	91.81	71.34	41.88	5.47
Pipeline_3-194	108	J-512	J-588	102.6	PVC	80	21.58	0.03	0.044	0.1	0.04	0.03	0
Pipeline_3-129	110	J-586	J-524	69.8	PVC	80	125.97	0.38	7.628	6.32	7.63	4.48	0.59
Pipeline_3-31	112	J-533	J-513	102.6	PVC	80	191.49	0.27	2.537	9.33	2.54	1.49	0.2
Pipeline_3-104	139	J-555	J-484	69.8	PVC	80	4.72	0.01	0.017	1.47	0.02	0.01	0
Pipeline_3-110	113	J-573	J-575	69.8	PVC	80	40.41	0.12	0.929	0.77	0.93	0.55	0.07
Pipeline_3-146	113	J-559	J-531	69.8	PVC	80	186.52	0.56	15.778	17.4	15.78	9.26	1.21

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-79	137	J-552	J-420	69.8	PVC	80	91.35	0.28	4.206	7.42	4.21	2.47	0.32
Pipeline_3-84	159	J-582	J-587	69.8	PVC	80	58.15	0.18	1.822	2.26	1.82	1.07	0.14
Pipeline_3-224	156	J-582	J-587	69.8	PVC	80	58.89	0.18	1.865	2.32	1.87	1.1	0.14
Pipeline_3-109	116	J-553	J-572	69.8	PVC	80	91.85	0.28	4.249	3.52	4.25	2.49	0.33
Pipeline_3-177	118	J-500	J-589	150	AC	60	23.42	0.02	0.014	0.02	0.01	0.01	0
Pipeline_3-18	118	J-549	J-464	102.6	PVC	80	235.9	0.33	3.733	4.98	3.73	2.19	0.29
Pipeline_3-49	118	J-522	J-546	102.6	PVC	80	136.63	0.19	1.358	1.86	1.36	0.8	0.1
Pipeline_3-163	120	J-501	J-520	69.8	PVC	80	303.32	0.92	38.828	59.68	38.83	22.8	2.98

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-102	120	J-555	J-571	69.8	PVC	80	101.37	0.31	5.1	5.28	5.1	3	0.39
Pipeline_3-229	152	J-509	J-580	69.8	PVC	80	180.52	0.55	14.85	16.25	14.85	8.72	1.14
Pipeline_3-228	158	J-580	J-564	69.8	PVC	80	19.66	0.06	0.245	0.58	0.25	0.14	0.02
Pipeline_3-118	123	J-505	J-590	150	AC	60	1229.16	0.81	21.266	27.55	21.27	12.49	1.63
Pipeline_3-112	131	J-563	J-558	150	AC	60	843.68	0.55	10.593	13.5	10.59	6.22	0.81
Pipeline_3-11	131	J-591	J-549	102.6	PVC	80	26.17	0.04	0.064	0.14	0.06	0.04	0.01
Pipeline_3-114	133	J-577	J-592	150	AC	60	2201.68	1.44	62.592	70.86	62.59	36.75	4.8
Pipeline_3-113	136	J-592	J-563	150	AC	60	1506.96	0.99	31.015	37.42	31.02	18.21	2.38

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-119	137	J-590	J-550	150	AC	60	897.04	0.59	11.867	15.63	11.87	6.97	0.91
Pipeline_3-121	142	J-494	J-518	102.6	PVC	80	617.62	0.86	22.192	45.21	22.19	13.03	1.7
Pipeline_3-55	152	J-593	J-430	102.6	PVC	80	30.24	0.04	0.083	0.19	0.08	0.05	0.01
Pipeline_3-148	157	J-537	J-560	69.8	PVC	80	89.63	0.27	4.061	2.46	4.06	2.38	0.31
Pipeline_3-182	159	J-520	J-570	200	MS	80	1.05	0	0	0.15	0	0	0
Pipeline_3-204	164	J-525	J-594	69.8	PVC	80	32.61	0.1	0.624	0.52	0.62	0.37	0.05
Pipeline_3-166	164	J-586	J-595	69.8	PVC	80	32.65	0.1	0.626	0.52	0.63	0.37	0.05
Pipeline_3-44	164	J-523	J-533	102.6	PVC	80	553.61	0.77	18.122	23.81	18.12	10.64	1.39

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m^3/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-19	170	J-501	J-464	102.6	PVC	80	556.13	0.78	18.275	29.12	18.28	10.73	1.4
Pipeline_3-22	189	J-570	J-568	150	AC	60	545.59	0.36	4.725	8.32	4.73	2.77	0.36
Pipeline_3-195	189	J-536	J-592	102.6	PVC	80	603.47	0.84	21.26	35.76	21.26	12.48	1.63
Pipeline_3-147	190	J-534	J-522	69.8	PVC	80	106.56	0.32	5.594	8.15	5.59	3.29	0.43
Pipeline_3-191	199	J-464	J-590	102.6	PVC	80	240.7	0.34	3.875	8.57	3.88	2.28	0.3
Pipeline_3-47	235	J-482	J-521	150	AC	60	143.9	0.09	0.4	0.37	0.4	0.24	0.03
Pipeline_3-178	257	J-583	J-500	150	AC	60	691.36	0.45	7.326	9.82	7.33	4.3	0.56
Pipeline_3-179	269	J-527	J-583	150	AC	60	381.55	0.25	2.436	3.03	2.44	1.43	0.19

Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (m³/day)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 4 Hours Supply	Headloss Gradient (m/km) 6 Hours Supply	Headloss Gradient (m/km) 8 Hours Supply	Headloss Gradient (m/km) 24 Hours Supply
Pipeline_3-190	303	J-560	J-598	150	AC	60	60.28	0.04	0.08	0.1	0.08	0.05	0.01
P-1	174	J-596	J-557	69.8	PVC	80	34.73	0.11	0.702	0.58	0.7	0.41	0.05
P-2	78	J-557	J-597	69.8	PVC	80	15.59	0.05	0.159	0.13	0.16	0.09	0.01

Node/ Junction results for Rajajipuram DMA

Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm^2) At present condition	Pressure (kg/cm^2) 4 Hours Supply	Pressure (kg/cm^2) 6 Hours Supply	Pressure (kg/cm^2) 8 Hours Supply	Pressure (kg/cm^2) 24 Hours Supply
J-418	123.1	0	140.7	0.89	-0.34	0.89	1.57	2.41
J-419	123.1	8.65	140.7	0.89	-0.34	0.89	1.57	2.41
J-420	126.5	12.16	140.78	0.6	-0.46	0.6	1.26	2.07
J-421	126.5	0	140.78	0.6	-0.46	0.6	1.26	2.07
J-422	124.2	0	140.69	0.68	-0.47	0.68	1.4	2.29
J-423	124.2	5.75	140.69	0.68	-0.47	0.68	1.4	2.29
J-424	125.5	0	141	1.21	0.26	1.21	1.66	2.21
J-425	125.5	8.14	141	1.21	0.26	1.21	1.66	2.21
J-426	125.1	6.18	141	1.23	0.28	1.23	1.69	2.25
J-427	125	6.24	141	1.24	0.29	1.24	1.7	2.26
J-428	127	10.15	140.61	0.2	-0.98	0.2	1.01	2
J-429	127	4.25	140.61	0.2	-0.98	0.2	1	2
J-430	124.2	9.95	140.7	0.68	-0.47	0.68	1.4	2.29
J-431	124.2	3.46	140.7	0.68	-0.47	0.68	1.4	2.29
J-432	126.9	7.8	140.75	0.55	-0.57	0.55	1.21	2.03
J-433	126.8	5.66	140.75	0.56	-0.56	0.56	1.22	2.04
J-434	125.2	3.84	141.03	1.3	0.35	1.3	1.72	2.25
J-435	125.2	7.39	141.04	1.33	0.38	1.33	1.74	2.25
J-436	128	6.62	140.7	0.31	-0.84	0.31	1.03	1.91
J-437	127.9	4.14	140.7	0.32	-0.83	0.32	1.04	1.92
J-438	125.3	4.69	140.64	0.5	-0.74	0.5	1.25	2.18
J-439	125.4	11.01	140.64	0.49	-0.74	0.49	1.24	2.17
J-440	125.2	6.38	140.69	0.57	-0.57	0.57	1.3	2.19
J-441	125.2	3.12	140.69	0.57	-0.57	0.57	1.3	2.19
J-442	124.3	11.09	140.64	0.6	-0.63	0.6	1.35	2.27
J-443	124.4	4.7	140.64	0.59	-0.65	0.59	1.34	2.26
J-444	126.9	13.61	140.26	-0.25	-1.94	-0.25	0.74	1.97
J-445	126.7	5.57	140.26	-0.23	-1.92	-0.23	0.76	1.99
J-446	125.2	2.09	141.47	2.29	1.58	2.29	2.3	2.32
J-447	125.1	9.33	141.46	2.27	1.56	2.27	2.3	2.33
J-449	123.9	3.62	140.69	0.71	-0.44	0.71	1.43	2.32
J-450	124	8.31	140.69	0.7	-0.45	0.7	1.42	2.31

Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm^2) At present condition	Pressure (kg/cm^2) 4 Hours Supply	Pressure (kg/cm^2) 6 Hours Supply	Pressure (kg/cm^2) 8 Hours Supply	Pressure (kg/cm^2) 24 Hours Supply
J-451	126.4	7.69	140.69	0.45	-0.69	0.45	1.18	2.07
J-452	126.4	8.67	140.69	0.45	-0.69	0.45	1.18	2.07
J-453	126.5	3.52	140.26	-0.21	-1.91	-0.21	0.78	2.01
J-454	125.3	3.73	141.48	2.29	1.59	2.29	2.3	2.31
J-455	126.5	0.65	140.26	-0.21	-1.91	-0.21	0.78	2.01
J-456	125.9	5.96	141	1.15	0.2	1.15	1.61	2.17
J-457	125.7	3.37	141	1.18	0.22	1.18	1.63	2.19
J-458	126.4	4.92	140.59	0.22	-0.99	0.22	1.04	2.05
J-459	126.5	3.25	140.59	0.21	-1	0.21	1.03	2.04
J-460	126.5	0.73	140.59	0.21	-1	0.21	1.03	2.04
J-461	124.8	6.38	140.73	0.61	-0.44	0.61	1.33	2.23
J-462	124.6	7.79	140.71	0.6	-0.47	0.6	1.34	2.25
J-463	127.4	6.61	140.69	0.36	-0.79	0.36	1.08	1.97
J-464	123.9	24.98	140.67	0.74	-0.52	0.74	1.45	2.32
J-465	123.7	7.43	140.69	0.8	-0.45	0.8	1.49	2.35
J-466	125.4	5.99	140.59	0.34	-0.87	0.34	1.15	2.15
J-467	125.5	5.25	140.59	0.32	-0.88	0.32	1.14	2.14
J-469	127	5.81	140.6	0.19	-1	0.19	1	2
J-470	126.5	0.85	140.66	0.33	-0.79	0.33	1.1	2.05
J-471	126.3	6.58	140.66	0.35	-0.77	0.35	1.12	2.07
J-472	125.5	6.54	141	1.19	0.24	1.19	1.65	2.21
J-473	126.8	5.98	140.59	0.2	-1.01	0.2	1.01	2.01
J-474	126.7	4.39	140.59	0.2	-1	0.2	1.02	2.02
J-475	126.9	0.87	140.69	0.41	-0.74	0.41	1.13	2.02
J-476	127.4	4.03	140.7	0.38	-0.77	0.38	1.09	1.97
J-477	127	6.69	140.71	0.43	-0.72	0.43	1.14	2.01
J-478	124	0.92	140.72	0.83	-0.38	0.83	1.49	2.32
J-479	124	8.37	140.72	0.83	-0.38	0.83	1.49	2.32
J-480	126.5	0.93	140.7	0.47	-0.68	0.47	1.18	2.06
J-481	121.6	5.14	140.75	1.12	-0.06	1.12	1.77	2.56
J-482	121.6	14.67	140.75	1.13	-0.06	1.13	1.77	2.56
J-483	126.7	7.87	140.59	0.2	-1.01	0.2	1.02	2.02
J-484	125.9	10.58	140.74	0.53	-0.51	0.53	1.24	2.12
J-485	125.8	8.41	140.73	0.52	-0.54	0.52	1.24	2.13

Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm^2) At present condition	Pressure (kg/cm^2) 4 Hours Supply	Pressure (kg/cm^2) 6 Hours Supply	Pressure (kg/cm^2) 8 Hours Supply	Pressure (kg/cm^2) 24 Hours Supply
J-486	126.3	1.13	140.59	0.23	-0.98	0.23	1.05	2.06
J-487	125.6	12.14	140.26	-0.12	-1.82	-0.12	0.87	2.1
J-488	125.5	1.16	140.26	-0.11	-1.81	-0.11	0.88	2.11
J-489	125.8	1.27	141.48	2.24	1.54	2.24	2.25	2.26
J-490	125.3	6.76	140.59	0.34	-0.87	0.34	1.15	2.16
J-491	124.7	4.82	140.69	0.62	-0.52	0.62	1.35	2.24
J-492	125.4	8.45	140.98	1.16	0.19	1.16	1.63	2.22
J-493	126.4	8.95	140.28	-0.14	-1.84	-0.14	0.83	2.02
J-494	126.2	11.43	140.28	-0.11	-1.8	-0.11	0.85	2.05
J-495	125.7	9.18	140.68	0.44	-0.65	0.44	1.2	2.13
J-496	126	6.85	140.59	0.26	-0.95	0.26	1.08	2.09
J-497	124.6	5.1	140.69	0.63	-0.51	0.63	1.36	2.25
J-498	124.8	8.26	140.69	0.61	-0.53	0.61	1.34	2.23
J-499	124.4	5.09	140.69	0.65	-0.49	0.65	1.38	2.27
J-500	122	20.2	140.39	0.51	-1.08	0.51	1.39	2.48
J-501	122.3	15.96	140.49	0.59	-0.85	0.59	1.42	2.46
J-502	125.8	7.94	140.69	0.51	-0.63	0.51	1.24	2.13
J-503	124.3	10.66	141.04	1.44	0.47	1.44	1.84	2.34
J-504	124.3	6.75	140.95	1.25	0.24	1.25	1.73	2.33
J-505	124.1	10.79	140.85	1.05	-0.03	1.05	1.62	2.33
J-506	123.6	9.43	140.75	0.91	-0.27	0.91	1.56	2.36
J-507	123.4	1.62	140.75	0.93	-0.25	0.93	1.58	2.38
J-508	123.5	6.61	141.08	1.62	0.68	1.62	1.98	2.43
J-509	123.1	11.41	141	1.52	0.49	1.52	1.94	2.46
J-510	125.2	1.71	141	1.22	0.27	1.22	1.68	2.24
J-511	129.5	9.37	140.7	0.17	-0.99	0.17	0.88	1.76
J-512	126.8	10.71	140.59	0.19	-1.03	0.19	1	2.01
J-513	125	10.85	140.98	1.2	0.23	1.2	1.67	2.26
J-514	124.7	11.93	140.69	0.63	-0.52	0.63	1.35	2.24
J-515	129.6	9.74	140.74	0.21	-0.89	0.21	0.9	1.76
J-516	129.2	7.52	140.73	0.23	-0.88	0.23	0.93	1.8
J-517	125.1	7.55	141.11	1.5	0.59	1.5	1.85	2.27
J-518	124.4	11.74	140.52	0.38	-0.98	0.38	1.22	2.25
J-519	124	7.24	140.61	0.55	-0.68	0.55	1.33	2.3

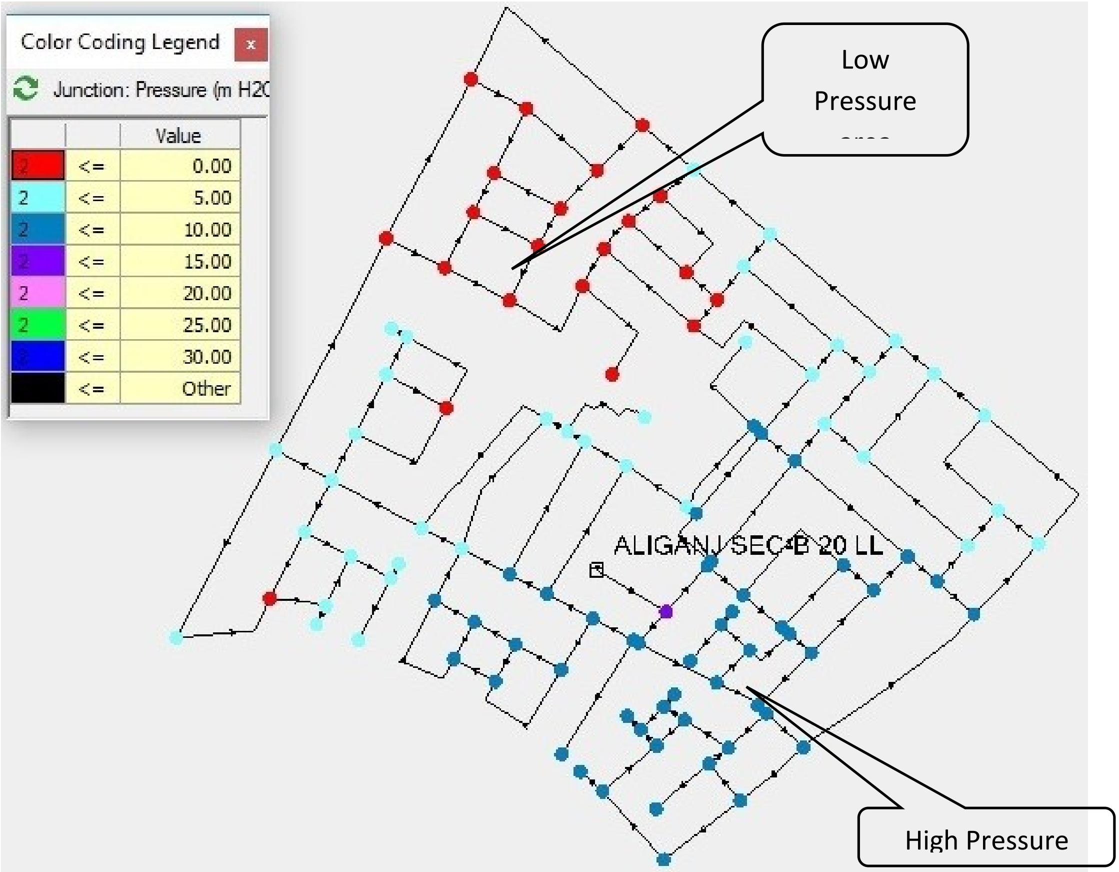
Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm^2) At present condition	Pressure (kg/cm^2) 4 Hours Supply	Pressure (kg/cm^2) 6 Hours Supply	Pressure (kg/cm^2) 8 Hours Supply	Pressure (kg/cm^2) 24 Hours Supply
J-520	122	15.92	140.75	1.08	-0.11	1.08	1.73	2.52
J-521	123.3	16.36	140.75	0.95	-0.24	0.95	1.6	2.39
J-522	122.9	17.38	140.75	1	-0.18	1	1.64	2.43
J-523	122	12.44	140.8	1.18	0.04	1.18	1.78	2.53
J-524	126.5	9.85	140.09	-0.77	-2.36	-0.77	0.46	1.97
J-525	126.7	13.08	140.09	-0.81	-2.39	-0.81	0.42	1.95
J-526	126.9	17.98	140.27	-0.24	-1.91	-0.24	0.75	1.97
J-527	127	35.99	140.27	-0.24	-1.91	-0.24	0.74	1.96
J-528	122.5	2.16	140.75	1.03	-0.15	1.03	1.68	2.47
J-529	124.5	7.74	141.13	1.62	0.7	1.62	1.94	2.34
J-530	125.4	10.52	141.22	1.75	0.87	1.75	1.98	2.26
J-531	122.5	10.05	140.95	1.47	0.41	1.47	1.94	2.51
J-532	124	10.78	141.11	1.61	0.69	1.61	1.95	2.38
J-533	122.2	15.95	140.94	1.45	0.41	1.45	1.94	2.53
J-534	122.9	14.26	140.81	1.1	-0.02	1.1	1.7	2.44
J-535	125.5	11.91	140.79	0.81	-0.33	0.81	1.42	2.18
J-536	126	14.39	140.8	0.78	-0.35	0.78	1.39	2.13
J-537	123.2	12.71	140.73	0.89	-0.27	0.89	1.56	2.4
J-538	123.3	11.66	140.64	0.69	-0.54	0.69	1.44	2.37
J-539	125.7	14.08	140.13	-0.55	-2.17	-0.55	0.61	2.06
J-540	126.4	2.29	140.59	0.22	-0.99	0.22	1.04	2.05
J-541	124.5	11.71	140.64	0.57	-0.66	0.57	1.33	2.25
J-542	127.4	13.6	140.17	-0.62	-2.24	-0.62	0.5	1.9
J-543	125.9	15.36	140.13	-0.59	-2.19	-0.59	0.59	2.04
J-544	122.4	10.49	140.7	0.94	-0.28	0.94	1.63	2.48
J-545	123.4	2.38	140.7	0.84	-0.38	0.84	1.53	2.38
J-546	122.6	10.94	140.76	1.04	-0.13	1.04	1.68	2.47
J-547	122.9	10.2	140.79	1.06	-0.07	1.06	1.68	2.44
J-548	125.9	8.27	140.6	0.3	-0.9	0.3	1.11	2.1
J-549	126.8	14.86	140.64	0.4	-0.87	0.4	1.13	2.03
J-550	123.9	14.53	140.65	0.65	-0.56	0.65	1.4	2.32
J-551	127.8	8.02	140.74	0.41	-0.69	0.41	1.09	1.94
J-552	128	14.32	140.74	0.39	-0.71	0.39	1.07	1.92
J-553	125.1	11.8	140.67	0.42	-0.63	0.42	1.21	2.19

Label	Elevation (m)	Demand (m³/day)	Hydraulic Grade (m)	Pressure (kg/cm²) At present condition	Pressure (kg/cm²) 4 Hours Supply	Pressure (kg/cm²) 6 Hours Supply	Pressure (kg/cm²) 8 Hours Supply	Pressure (kg/cm²) 24 Hours Supply
J-554	127.8	7.97	140.74	0.4	-0.69	0.4	1.09	1.94
J-555	127.4	15.46	140.73	0.38	-0.68	0.38	1.09	1.97
J-556	125.4	15.57	140.12	-0.57	-2.17	-0.57	0.62	2.08
J-557	123.9	15.15	140.11	-0.45	-2.04	-0.45	0.75	2.23
J-558	125.7	12.14	140.8	0.66	-0.33	0.66	1.32	2.15
J-559	123.8	12.51	140.88	1.16	0.09	1.16	1.7	2.36
J-560	122.7	25.52	140.74	1	-0.19	1	1.65	2.45
J-561	124.4	10.84	140.51	0.37	-0.99	0.37	1.21	2.25
J-562	125.6	5.83	140.79	0.63	-0.35	0.63	1.31	2.16
J-563	125.5	16.04	140.86	0.81	-0.13	0.81	1.43	2.18
J-564	124.2	13.65	140.92	1.19	0.14	1.19	1.7	2.33
J-565	125.6	2.84	140.09	-0.7	-2.28	-0.7	0.53	2.06
J-566	128.5	14.17	140.2	-0.63	-2.27	-0.63	0.45	1.79
J-567	124.9	14.72	140.18	-0.33	-1.97	-0.33	0.78	2.15
J-568	124.8	17.26	140.8	0.89	-0.23	0.89	1.5	2.25
J-569	125.4	3.05	140.51	0.27	-1.09	0.27	1.11	2.15
J-570	122.4	20.48	140.75	1.04	-0.14	1.04	1.69	2.48
J-571	125.7	13.69	140.71	0.49	-0.58	0.49	1.23	2.14
J-572	124.6	16.6	140.65	0.42	-0.62	0.42	1.23	2.23
J-573	126.1	16.45	140.65	0.27	-0.77	0.27	1.08	2.08
J-574	123	4.83	140.7	0.88	-0.34	0.88	1.57	2.42
J-575	125.4	12.85	140.66	0.35	-0.7	0.35	1.16	2.15
J-576	125.6	3.71	140.66	0.33	-0.72	0.33	1.14	2.13
J-577	124.6	15.9	141.39	2.16	1.41	2.16	2.25	2.37
J-578	124.1	4.1	141	1.33	0.37	1.33	1.79	2.35
J-579	126	5.11	140.51	0.2	-1.16	0.2	1.05	2.09
J-580	122.6	19.76	140.91	1.35	0.3	1.35	1.86	2.49
J-581	124.1	4.4	141	1.33	0.37	1.33	1.79	2.35
J-582	127.9	20.55	140.63	0.15	-1.02	0.15	0.94	1.91
J-583	125.7	30.76	140.3	-0.05	-1.7	-0.05	0.91	2.1
J-584	125.7	4.72	140.26	-0.14	-1.83	-0.14	0.86	2.09
J-585	127	4.85	140.07	-0.9	-2.48	-0.9	0.36	1.91
J-586	126.3	18.48	140.07	-0.83	-2.41	-0.83	0.43	1.98
J-587	126.3	21.4	140.62	0.28	-0.89	0.28	1.08	2.07

Label	Elevation (m)	Demand (m^3/day)	Hydraulic Grade (m)	Pressure (kg/cm²) At present condition	Pressure (kg/cm²) 4 Hours Supply	Pressure (kg/cm²) 6 Hours Supply	Pressure (kg/cm²) 8 Hours Supply	Pressure (kg/cm²) 24 Hours Supply
J-588	126.3	5.39	140.59	0.23	-0.98	0.23	1.05	2.06
J-589	121.5	5.85	140.39	0.56	-1.03	0.56	1.44	2.53
J-590	122.7	22.85	140.73	0.93	-0.23	0.93	1.61	2.45
J-591	125.4	6.54	140.64	0.54	-0.73	0.54	1.27	2.17
J-592	127.4	22.8	141.05	1.04	0.19	1.04	1.48	2.02
J-593	122	7.56	140.69	0.9	-0.25	0.9	1.62	2.51
J-594	125.1	8.15	140.08	-0.66	-2.24	-0.66	0.58	2.1
J-595	126.1	8.16	140.06	-0.82	-2.39	-0.82	0.44	2
J-596	126.2	8.68	140.11	-0.7	-2.28	-0.7	0.51	2
J-597	122.3	3.9	140.11	-0.3	-1.88	-0.3	0.91	2.39
J-598	124.9	15.06	140.74	0.78	-0.41	0.78	1.43	2.23

Aliganj Sector-B DMA

In case Aliganj DMA, the total flow through this DMA is 1.87 MLD. This demand is applied to that DMA. As the supply for this DMA is for 3 hours, the peak factor is 8.



Pipe results for Aliganj Sector B- DMA

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-13	J-20	J-21	250.0	CI	70.0	6	46.271	1.035	6.410	23.142	1.042	0.135
P-17	J-28	J-4	250.0	CI	70.0	6	69.432	1.553	13.593	49.071	2.211	0.289
P-35	J-62	J-63	190.8	PVC	110.0	10	11.375	0.398	1.417	5.114	0.231	0.030
P-36	J-64	J-65	105.0	PVC	110.0	11	1.483	0.171	0.596	2.155	0.097	0.012
P-42	J-75	J-76	105.0	PVC	110.0	12	5.025	0.580	5.722	20.660	0.931	0.122
P-43	J-77	J-78	190.8	PVC	110.0	12	24.118	0.844	5.699	20.572	0.927	0.121
P-64	J-116	J-117	100.0	AC	65.0	16	0.129	0.016	0.022	0.079	0.003	0.001
P-66	J-120	J-121	105.0	PVC	110.0	17	0.132	0.015	0.007	0.024	0.001	0.000
P-70	J-128	J-129	105.0	PVC	110.0	17	0.136	0.016	0.007	0.026	0.001	0.000
P-72	J-132	J-133	152.6	PVC	110.0	17	0.137	0.007	0.001	0.004	0.000	0.000
P-92	J-167	J-168	100.0	AC	65.0	19	0.154	0.020	0.030	0.108	0.005	0.000
P-102	J-186	J-187	100.0	AC	65.0	20	5.486	0.698	22.625	81.676	3.678	0.481
P-103	J-188	J-189	105.0	PVC	110.0	21	0.166	0.019	0.010	0.037	0.002	0.000
P-137	J-167	J-242	100.0	AC	65.0	23	0.410	0.052	0.186	0.671	0.030	0.004
P-154	J-116	J-268	100.0	AC	65.0	25	1.064	0.136	1.085	3.918	0.176	0.023
P-156	J-187	J-271	100.0	AC	65.0	25	3.400	0.433	9.326	33.667	1.516	0.198
P-163	J-280	J-281	100.0	AC	65.0	26	0.271	0.034	0.086	0.311	0.014	0.002
P-235	J-63	J-367	190.8	PVC	110.0	30	11.793	0.412	1.515	5.468	0.246	0.032

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-245	J-380	J-381	100.0	AC	65.0	30	0.241	0.031	0.069	0.250	0.011	0.002
P-288	J-167	J-116	100.0	AC	65.0	33	0.344	0.044	0.134	0.484	0.022	0.003
P-325	J-463	J-464	100.0	AC	65.0	36	1.188	0.151	1.330	4.800	0.216	0.028
P-359	J-509	J-510	100.0	CI	70.0	38	2.108	0.268	3.354	12.109	0.545	0.071
P-383	J-132	J-529	152.6	PVC	110.0	39	1.355	0.074	0.082	0.295	0.013	0.002
P-386	J-242	J-268	100.0	AC	65.0	39	0.842	0.107	0.703	2.538	0.114	0.015
P-389	J-534	J-535	190.8	PVC	110.0	39	29.325	1.026	8.185	29.548	1.331	0.174
P-397	J-540	J-541	100.0	AC	65.0	40	1.295	0.165	1.562	5.639	0.254	0.033
P-402	J-544	J-545	190.8	PVC	110.0	40	12.456	0.436	1.676	6.051	0.273	0.036
P-414	J-562	J-563	100.0	AC	65.0	41	0.571	0.073	0.343	1.238	0.056	0.007
P-426	J-510	J-575	100.0	CI	70.0	41	2.649	0.337	5.123	18.492	0.833	0.109
P-437	J-464	J-581	80.0	AC	65.0	42	2.053	0.408	10.868	39.235	1.767	0.231
P-443	J-587	J-588	100.0	AC	65.0	42	2.444	0.311	5.062	18.273	0.823	0.108
P-451	J-4	J-598	250.0	CI	70.0	42	94.662	2.117	24.134	87.122	3.924	0.513

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-454	J-540	J-562	100.0	AC	65.0	43	3.772	0.480	11.309	40.827	1.839	0.240
P-461	J-607	J-608	190.8	PVC	110.0	43	46.708	1.634	19.381	69.967	3.151	0.412
P-464	J-611	J-612	105.0	PVC	110.0	43	0.016	0.002	0.000	0.000	0.000	0.000
P-465	J-613	J-614	105.0	PVC	110.0	43	1.317	0.152	0.479	1.731	0.078	0.010
P-470	J-129	J-620	105.0	PVC	110.0	43	1.109	0.128	0.349	1.259	0.057	0.008
P-476	J-65	J-628	105.0	PVC	110.0	44	8.690	1.004	15.784	56.980	2.566	0.336
P-479	J-575	J-631	100.0	CI	70.0	44	4.723	0.601	14.947	53.960	2.430	0.318
P-485	J-636	J-509	100.0	CI	70.0	44	3.044	0.388	6.626	23.919	1.077	0.141
P-486	J-464	J-587	100.0	AC	65.0	44	4.203	0.535	13.817	49.878	2.247	0.294
P-491	J-529	J-63	152.6	PVC	110.0	56	1.180	0.065	0.063	0.228	0.010	0.001
P-504	J-650	J-651	100.0	CI	70.0	45	1.201	0.153	1.183	4.270	0.192	0.025
P-508	J-654	J-655	100.0	CI	70.0	45	0.685	0.087	0.418	1.509	0.068	0.009
P-525	J-669	J-670	190.8	PVC	110.0	46	40.662	1.422	14.993	54.126	2.438	0.319
P-533	J-673	J-612	105.0	PVC	110.0	46	2.231	0.258	1.272	4.592	0.207	0.027

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-549	J-688	J-121	105.0	PVC	110.0	47	1.763	0.204	0.822	2.968	0.134	0.017
P-554	J-689	J-28	250.0	CI	70.0	47	66.834	1.495	12.666	45.724	2.059	0.269
P-555	J-20	J-690	190.8	PVC	110.0	47	29.158	1.020	8.098	29.236	1.317	0.172
P-557	J-691	J-529	152.6	PVC	110.0	47	3.660	0.200	0.515	1.859	0.084	0.011
P-566	J-697	J-698	100.0	AC	65.0	47	1.651	0.210	2.449	8.840	0.398	0.052
P-574	J-691	J-77	190.8	PVC	110.0	48	19.015	0.665	3.669	13.245	0.597	0.078
P-575	J-613	J-611	105.0	PVC	110.0	48	3.032	0.350	2.246	8.107	0.365	0.048
P-576	J-612	J-614	105.0	PVC	110.0	48	3.331	0.385	2.673	9.651	0.435	0.057
P-580	J-698	J-535	100.0	AC	65.0	48	5.806	0.739	25.133	90.732	4.086	0.534
P-590	J-628	J-710	100.0	AC	65.0	49	8.187	1.042	47.492	171.448	7.722	1.010
P-595	J-711	J-132	152.6	PVC	110.0	49	0.386	0.021	0.008	0.029	0.001	0.000
P-599	J-186	J-715	100.0	AC	65.0	49	5.478	0.697	22.564	81.457	3.669	0.480
P-602	J-534	J-545	152.6	PVC	110.0	49	15.080	0.825	7.091	25.598	1.153	0.151
P-604	J-280	J-718	100.0	AC	65.0	49	1.989	0.253	3.456	12.477	0.562	0.073

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-626	J-535	J-727	190.8	PVC	110.0	50	22.428	0.784	4.981	17.982	0.810	0.106
P-636	J-78	J-737	190.8	PVC	110.0	51	19.600	0.686	3.881	14.011	0.631	0.083
P-638	J-21	J-76	105.0	PVC	110.0	72	8.578	0.991	15.411	55.634	2.506	0.328
P-640	J-690	J-62	190.8	PVC	110.0	51	16.344	0.572	2.772	10.008	0.451	0.059
P-648	J-563	J-742	190.8	PVC	110.0	52	22.919	0.802	5.185	18.718	0.843	0.110
P-652	J-710	J-745	100.0	AC	65.0	52	2.423	0.309	4.982	17.986	0.810	0.106
P-658	J-78	J-281	100.0	AC	65.0	52	3.603	0.459	10.386	37.494	1.689	0.221
P-664	J-268	J-281	100.0	AC	65.0	53	2.835	0.361	6.661	24.046	1.083	0.142
P-665	J-750	J-688	105.0	PVC	110.0	53	2.706	0.313	1.819	6.566	0.296	0.039
P-666	J-608	J-689	250.0	CI	70.0	53	54.208	1.212	8.595	31.026	1.397	0.183
P-671	J-755	J-756	105.0	PVC	110.0	53	7.488	0.865	11.982	43.255	1.948	0.255
P-673	J-614	J-757	105.0	PVC	110.0	53	5.793	0.669	7.448	26.888	1.211	0.158
P-676	J-697	J-758	100.0	AC	65.0	54	2.666	0.339	5.946	21.463	0.967	0.126
P-679	J-651	J-760	100.0	CI	70.0	54	2.620	0.334	5.019	18.119	0.816	0.107

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-700	J-670	J-607	190.8	PVC	110.0	55	42.906	1.501	16.561	59.786	2.693	0.352
P-724	J-688	J-188	105.0	PVC	110.0	56	0.296	0.034	0.030	0.109	0.005	0.001
P-736	J-782	J-188	105.0	PVC	110.0	57	1.531	0.177	0.633	2.287	0.103	0.013
P-757	J-670	J-673	105.0	PVC	110.0	59	1.524	0.176	0.628	2.267	0.102	0.013
P-759	J-756	J-750	105.0	PVC	110.0	60	5.902	0.682	7.711	27.836	1.254	0.164
P-772	J-689	J-757	105.0	PVC	110.0	61	11.348	1.311	25.873	93.403	4.207	0.550
P-787	J-611	J-673	105.0	PVC	110.0	139	1.226	0.142	0.420	1.516	0.068	0.009
P-788	J-794	J-650	100.0	CI	70.0	63	0.480	0.061	0.217	0.782	0.035	0.005
P-791	J-598	J-20	250.0	CI	70.0	63	76.349	1.708	16.207	58.506	2.635	0.344
P-795	J-796	J-797	100.0	CI	70.0	64	4.109	0.523	11.548	41.687	1.878	0.245
P-796	J-655	J-798	100.0	CI	70.0	64	1.483	0.189	1.750	6.316	0.284	0.037
P-806	J-802	J-756	190.8	PVC	110.0	64	23.984	0.839	5.640	20.361	0.917	0.120
P-810	J-760	J-804	100.0	CI	70.0	65	4.280	0.545	12.454	44.958	2.025	0.265
P-836	J-814	J-798	100.0	CI	70.0	67	4.760	0.606	15.165	54.747	2.466	0.322

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-838	J-742	J-816	190.8	PVC	110.0	67	22.422	0.784	4.979	17.974	0.810	0.106
P-858	J-620	J-755	105.0	PVC	110.0	68	3.184	0.368	2.459	8.877	0.400	0.052
P-860	J-757	J-613	105.0	PVC	110.0	140	3.542	0.409	2.995	10.813	0.487	0.064
P-864	J-804	J-631	200.0	AC	65.0	69	8.944	0.285	1.912	6.902	0.311	0.041
P-873	J-710	J-562	100.0	AC	65.0	70	4.414	0.562	15.129	54.616	2.460	0.321
P-878	J-620	J-832	105.0	PVC	110.0	70	0.636	0.073	0.125	0.450	0.020	0.003
P-881	J-280	J-834	100.0	AC	65.0	71	0.562	0.072	0.333	1.203	0.054	0.007
P-883	J-121	J-835	105.0	PVC	110.0	71	0.564	0.065	0.100	0.360	0.016	0.002
P-885	J-381	J-242	100.0	AC	65.0	72	0.630	0.080	0.411	1.485	0.067	0.009
P-904	J-798	J-794	100.0	CI	70.0	74	1.659	0.211	2.154	7.776	0.350	0.046
P-906	J-797	J-654	100.0	CI	70.0	74	2.212	0.282	3.669	13.246	0.597	0.078
P-908	J-655	J-650	100.0	CI	70.0	74	0.719	0.092	0.458	1.653	0.074	0.010
P-912	J-715	J-75	105.0	PVC	110.0	75	2.151	0.248	1.189	4.293	0.193	0.025
P-928	J-794	J-636	100.0	CI	70.0	113	0.161	0.021	0.029	0.103	0.005	0.001

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-930	J-750	J-782	105.0	PVC	110.0	76	1.697	0.196	0.766	2.766	0.125	0.016
P-934	J-367	J-77	152.6	PVC	110.0	77	6.189	0.338	1.363	4.919	0.222	0.029
P-940	J-654	J-651	100.0	CI	70.0	77	0.026	0.003	0.001	0.004	0.000	0.000
P-946	J-581	J-510	80.0	AC	65.0	79	0.711	0.142	1.526	5.510	0.248	0.032
P-949	J-541	J-65	100.0	AC	65.0	79	7.371	0.939	39.104	141.167	6.358	0.831
P-956	J-849	J-187	105.0	PVC	110.0	109	0.862	0.100	0.219	0.790	0.036	0.005
P-969	ALIGANJ SEC-B 20 LL	J-598	250.0	CI	70.0	82	173.148	3.527	135.862	490.462	22.090	2.888
P-970	J-575	J-581	80.0	AC	65.0	113	0.507	0.101	0.815	2.944	0.133	0.017
P-980	J-832	J-129	105.0	PVC	110.0	114	0.412	0.048	0.056	0.201	0.009	0.001
P-985	J-718	J-737	152.6	PVC	110.0	84	7.774	0.425	2.079	7.504	0.338	0.044
P-994	J-855	J-64	105.0	PVC	110.0	118	0.936	0.108	0.255	0.919	0.041	0.005
P-1005	J-691	J-4	190.8	PVC	110.0	89	24.139	0.844	5.708	20.605	0.928	0.121
P-1006	J-544	J-62	152.6	PVC	110.0	89	3.771	0.206	0.544	1.965	0.089	0.012
P-1007	J-545	J-367	152.6	PVC	110.0	90	4.045	0.221	0.620	2.238	0.101	0.013

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1024	J-381	J-859	100.0	AC	65.0	94	2.421	0.308	4.975	17.961	0.809	0.106
P-1029	J-860	J-636	100.0	AC	65.0	124	0.981	0.125	0.933	3.368	0.152	0.020
P-1033	J-797	J-760	100.0	CI	70.0	96	0.045	0.006	0.003	0.010	0.000	0.000
P-1034	J-832	J-755	105.0	PVC	110.0	133	2.288	0.264	1.333	4.814	0.217	0.028
P-1040	J-697	J-816	100.0	AC	65.0	137	2.429	0.309	5.005	18.068	0.814	0.106
P-1041	J-727	J-758	190.8	PVC	110.0	98	28.498	0.997	7.762	28.022	1.262	0.165
P-1043	J-859	J-718	152.6	PVC	110.0	99	3.946	0.216	0.592	2.137	0.096	0.013
P-1049	J-631	J-588	200.0	AC	65.0	102	15.363	0.489	5.207	18.796	0.847	0.111
P-1055	J-865	J-782	105.0	PVC	110.0	117	1.818	0.210	0.871	3.144	0.142	0.019
P-1059	J-756	J-669	190.8	PVC	110.0	105	39.610	1.385	14.283	51.561	2.322	0.304
P-1061	J-65	J-76	105.0	PVC	110.0	105	2.054	0.237	1.092	3.942	0.178	0.023
P-1063	J-75	J-64	105.0	PVC	110.0	108	1.331	0.154	0.489	1.764	0.079	0.010
P-1064	J-544	J-690	190.8	PVC	110.0	147	10.872	0.380	1.303	4.704	0.212	0.028
P-1074	J-745	J-742	100.0	AC	65.0	111	2.317	0.295	4.585	16.552	0.746	0.097

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1097	J-509	J-463	100.0	AC	65.0	120	2.540	0.323	5.435	19.619	0.884	0.115
P-1103	J-587	J-540	100.0	AC	65.0	125	3.428	0.436	9.472	34.194	1.540	0.201
P-1118	J-463	J-541	100.0	AC	65.0	161	3.862	0.492	11.814	42.648	1.921	0.251
P-1123	J-21	J-628	250.0	CI	70.0	134	36.013	0.805	4.030	14.548	0.655	0.086
P-1130	J-28	J-877	150.0	AC	65.0	137	1.088	0.062	0.157	0.567	0.026	0.003
P-1133	J-745	J-698	100.0	AC	65.0	139	2.292	0.292	4.493	16.219	0.731	0.096
P-1139	J-816	J-758	190.8	PVC	110.0	191	23.121	0.809	5.270	19.026	0.857	0.112
P-1154	J-628	J-534	190.8	PVC	110.0	151	16.145	0.565	2.710	9.782	0.441	0.058
P-1156	J-715	J-608	152.6	PVC	110.0	154	5.522	0.302	1.103	3.983	0.179	0.023
P-1158	J-186	J-607	100.0	AC	65.0	156	1.791	0.228	2.847	10.277	0.463	0.060
P-1160	J-670	J-271	100.0	AC	65.0	162	1.219	0.155	1.395	5.037	0.227	0.030
P-1167	J-588	J-563	200.0	AC	65.0	168	20.279	0.646	8.707	31.432	1.416	0.185
P-1168	J-271	J-669	100.0	AC	65.0	189	1.639	0.209	2.414	8.713	0.392	0.051
P-1171	J-796	J-804	150.0	AC	65.0	267	1.491	0.084	0.281	1.015	0.046	0.006

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1174	J-814	J-796	190.8	PVC	110.0	184	6.693	0.234	0.530	1.915	0.086	0.011
P-1184	J-802	J-865	190.8	PVC	110.0	216	4.457	0.156	0.250	0.902	0.041	0.005
P-1185	J-737	J-727	152.6	PVC	110.0	222	9.000	0.492	2.726	9.841	0.443	0.058
P-1189	J-802	J-814	190.8	PVC	110.0	244	15.369	0.538	2.474	8.930	0.402	0.053

Node/ Junction results for Aliganj Sector B- DMA

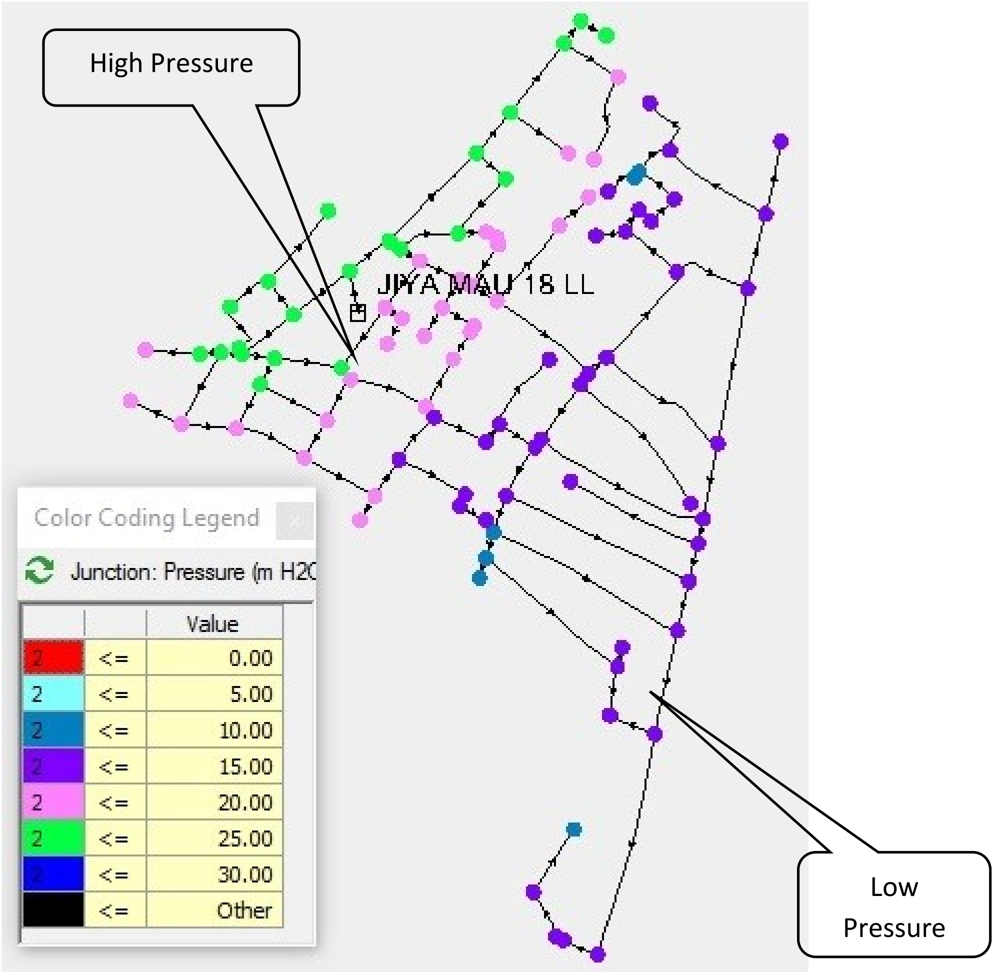
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-3	118.04	0.000	126.92	8.86	-22.88	19.04	20.76
J-4	118.04	1.091	126.92	8.86	-22.88	19.04	20.76
J-20	119.45	0.920	126.92	7.45	-24.29	17.63	19.35
J-21	119.63	1.680	126.88	7.23	-24.60	17.45	19.17
J-28	117.98	1.510	126.83	8.84	-23.12	19.09	20.82
J-62	120.05	1.198	126.39	6.33	-26.77	16.95	18.74
J-63	119.88	0.762	126.38	6.49	-26.65	17.12	18.91
J-64	119.13	1.878	125.65	6.51	-28.54	17.75	19.65
J-65	119.21	1.890	125.65	6.43	-28.59	17.67	19.57
J-75	120.74	1.543	125.70	4.95	-29.95	16.15	18.04
J-76	120.46	1.500	125.77	5.30	-29.43	16.44	18.32
J-77	118.75	1.086	126.23	7.47	-26.06	18.22	20.04
J-78	118.58	0.914	126.16	7.57	-26.14	18.38	20.21
J-116	118.54	0.591	125.23	6.68	-29.44	18.27	20.22
J-117	118.83	0.129	125.23	6.39	-29.72	17.98	19.94
J-120	120.13	0.132	121.26	1.13	-45.34	16.03	18.55
J-121	120.07	1.067	121.26	1.19	-45.28	16.10	18.62
J-128	120.60	0.136	121.03	0.44	-46.62	15.53	18.08
J-129	120.85	1.385	121.03	0.19	-46.87	15.29	17.84
J-132	119.42	0.832	126.38	6.95	-26.19	17.58	19.37
J-133	119.95	0.137	126.38	6.42	-26.72	17.05	18.84
J-167	117.89	0.601	125.23	7.33	-28.80	18.92	20.88
J-168	118.18	0.154	125.23	7.03	-29.10	18.62	20.58
J-186	120.35	1.783	124.51	4.15	-33.87	16.35	18.40
J-187	120.73	1.224	124.04	3.30	-35.92	15.89	18.01
J-188	121.17	1.068	121.30	0.13	-46.24	15.00	17.51
J-189	121.12	0.166	121.30	0.18	-46.19	15.05	17.56
J-242	117.59	1.062	125.23	7.63	-28.49	19.21	21.17
J-268	118.33	0.928	125.26	6.91	-29.13	18.48	20.43
J-271	121.47	2.980	123.81	2.33	-37.50	15.11	17.27
J-280	117.72	1.156	125.62	7.88	-27.24	19.15	21.05
J-281	118.15	1.039	125.61	7.45	-27.67	18.72	20.63
J-367	119.46	1.558	126.33	6.86	-26.39	17.53	19.33
J-380	116.33	0.241	125.26	8.91	-27.14	20.48	22.43
J-381	116.16	1.551	125.26	9.08	-26.96	20.65	22.60
J-463	120.99	2.510	120.66	-0.33	-48.36	15.08	17.68
J-464	120.84	0.963	120.71	-0.13	-48.03	15.24	17.84
J-509	120.87	1.603	120.01	-0.86	-50.60	15.09	17.79

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-510	121.07	1.253	120.13	-0.93	-50.33	14.92	17.59
J-529	119.80	1.125	126.38	6.57	-26.56	17.20	18.99
J-534	120.30	1.900	125.93	5.62	-28.69	16.62	18.48
J-535	120.11	1.091	125.61	5.48	-29.66	16.76	18.66
J-540	119.75	1.640	122.50	2.74	-40.50	16.62	18.96
J-541	119.55	2.214	122.56	3.00	-40.08	16.83	19.16
J-544	120.00	2.188	126.34	6.33	-26.90	16.99	18.79
J-545	119.58	1.420	126.28	6.69	-26.71	17.40	19.21
J-562	119.75	1.213	122.98	3.22	-38.77	16.70	18.97
J-563	119.46	2.068	122.99	3.53	-38.43	16.99	19.26
J-575	121.04	1.567	120.35	-0.69	-49.54	14.98	17.62
J-581	120.87	1.849	120.25	-0.62	-49.70	15.13	17.79
J-587	120.40	1.669	121.32	0.91	-45.41	15.78	18.29
J-588	120.50	2.472	121.53	1.03	-44.74	15.71	18.19
J-598	117.35	2.137	127.94	10.56	-18.51	19.89	21.47
J-607	118.46	2.011	124.95	6.48	-30.38	18.31	20.30
J-608	117.57	1.977	125.78	8.20	-26.50	19.33	21.21
J-611	118.00	1.822	124.13	6.12	-32.88	18.63	20.74
J-612	118.34	1.085	124.13	5.78	-33.22	18.29	20.40
J-613	118.70	1.827	124.24	5.52	-33.19	17.94	20.04
J-614	118.48	1.144	124.26	5.76	-32.90	18.17	20.26
J-620	120.56	1.439	121.05	0.49	-46.52	15.58	18.12
J-628	119.50	2.991	126.34	6.82	-26.41	17.49	19.29
J-631	120.69	1.696	121.00	0.31	-46.84	15.44	17.99
J-636	120.48	2.224	119.72	-0.77	-51.26	15.43	18.17
J-650	121.48	1.440	119.73	-1.74	-52.19	14.45	17.18
J-651	121.43	1.393	119.79	-1.64	-51.95	14.51	17.23
J-654	121.28	1.554	119.79	-1.49	-51.80	14.65	17.38
J-655	121.46	1.448	119.77	-1.69	-52.04	14.47	17.20
J-669	120.51	2.690	123.35	2.83	-38.19	15.99	18.22
J-670	119.59	2.549	124.03	4.44	-34.81	17.03	19.15
J-673	118.80	1.933	124.07	5.26	-33.89	17.82	19.94
J-688	120.91	1.240	121.30	0.39	-45.98	15.27	17.78
J-689	117.50	1.278	126.24	8.72	-24.78	19.47	21.29
J-690	120.67	1.942	126.54	5.85	-26.88	16.35	18.12
J-691	119.02	1.464	126.41	7.38	-25.69	17.98	19.77
J-697	123.68	1.888	124.28	0.60	-38.00	12.99	15.08
J-698	122.06	1.863	124.40	2.33	-35.97	14.62	16.69
J-710	119.09	1.349	124.03	4.93	-34.33	17.52	19.65

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-711	118.75	0.386	126.38	7.62	-25.52	18.25	20.04
J-715	120.77	2.196	125.61	4.83	-30.31	16.10	18.00
J-718	118.10	1.839	125.79	7.68	-27.00	18.80	20.68
J-727	120.18	2.930	125.36	5.17	-30.63	16.65	18.59
J-737	117.44	2.826	125.96	8.51	-25.71	19.49	21.34
J-742	119.96	1.820	123.26	3.30	-37.96	16.54	18.77
J-745	120.28	2.398	123.77	3.48	-36.45	16.29	18.46
J-750	120.80	1.500	121.40	0.59	-45.52	15.39	17.89
J-755	119.76	2.016	121.22	1.45	-45.12	16.40	18.92
J-756	120.33	2.235	121.86	1.52	-43.40	15.93	18.36
J-757	118.69	2.012	124.66	5.96	-31.67	18.03	20.07
J-758	122.00	2.711	124.60	2.59	-35.18	14.71	16.76
J-760	121.62	1.705	120.06	-1.56	-51.16	14.36	17.04
J-782	121.85	1.984	121.34	-0.52	-46.79	14.33	16.83
J-794	121.22	1.978	119.72	-1.50	-51.98	14.70	17.43
J-796	121.10	4.075	120.79	-0.30	-47.99	15.00	17.58
J-797	121.35	1.851	120.06	-1.29	-50.89	14.63	17.31
J-798	121.15	1.618	119.88	-1.27	-51.34	14.79	17.50
J-802	119.46	4.158	121.49	2.03	-43.83	16.75	19.23
J-804	121.06	3.174	120.87	-0.19	-47.68	15.05	17.62
J-814	121.88	3.917	120.89	-0.99	-48.42	14.23	16.80
J-816	121.01	3.128	123.59	2.58	-37.82	15.53	17.72
J-832	122.17	2.513	121.04	-1.12	-48.16	13.97	16.52
J-834	116.55	0.562	125.59	9.03	-26.16	20.31	22.22
J-835	120.45	0.564	121.25	0.80	-45.69	15.71	18.23
J-849	120.71	0.862	124.02	3.30	-35.98	15.90	18.03
J-855	120.64	0.936	125.62	4.97	-30.15	16.24	18.14
J-859	116.08	1.525	125.73	9.63	-25.20	20.80	22.69
J-860	120.31	0.981	119.60	-0.70	-51.50	15.59	18.34
J-865	119.94	2.639	121.44	1.49	-44.51	16.25	18.74
J-877	117.22	1.088	126.81	9.58	-22.43	19.85	21.58

Jiya Mau DMA

In case of Jiya Mau DMA, the total flow through this DMA is 1.28 MLD. This demand is applied to that DMA. As the supply for this DMA is for 3 hours, the peak factor is 8.



The results of calibration are presented in table below:

Pipe results for Jiya Mau DMA

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-16	J-26	J-27	105.0	PVC	110.0	6	11.241	1.298	25.424	91.781	4.134	0.539
P-21	J-35	J-36	105.0	PVC	110.0	7	0.673	0.078	0.139	0.498	0.022	0.003
P-23	J-39	J-40	150.0	AC	65.0	7	2.302	0.130	0.629	2.270	0.102	0.012
P-29	J-50	J-51	150.0	AC	65.0	9	7.591	0.430	5.728	20.680	0.931	0.121
P-37	J-26	J-66	105.0	PVC	110.0	11	11.410	1.318	26.138	94.359	4.251	0.556
P-38	J-67	J-68	152.6	PVC	110.0	11	30.636	1.675	26.350	95.123	4.284	0.560
P-41	J-73	J-74	105.0	PVC	110.0	12	0.647	0.075	0.128	0.464	0.021	0.002
P-44	J-79	J-80	152.6	PVC	110.0	12	43.286	2.367	49.980	180.428	8.126	1.063
P-45	J-81	J-82	152.6	PVC	110.0	12	11.718	0.641	4.444	16.043	0.723	0.094
P-46	J-83	J-84	200.0	AC	65.0	13	22.371	0.712	10.443	37.699	1.698	0.222
P-58	J-105	J-106	105.0	PVC	110.0	15	2.249	0.260	1.292	4.663	0.210	0.027
P-73	J-134	J-135	150.0	AC	65.0	18	0.175	0.010	0.005	0.019	0.001	0.000
P-78	J-142	J-143	250.0	CI	70.0	18	0.706	0.016	0.003	0.010	0.001	0.000
P-82	J-150	J-151	105.0	PVC	110.0	19	1.166	0.135	0.383	1.382	0.062	0.008
P-86	J-151	J-157	105.0	PVC	110.0	19	11.640	1.344	27.122	97.912	4.410	0.576
P-91	J-165	J-166	100.0	AC	65.0	19	0.191	0.024	0.045	0.162	0.007	0.001
P-97	J-177	J-178	152.6	PVC	110.0	20	25.010	1.367	18.096	65.326	2.942	0.385
P-101	J-80	J-185	152.6	PVC	110.0	20	38.916	2.128	41.038	148.149	6.673	0.872
P-112	J-204	J-81	152.6	PVC	110.0	22	23.649	1.293	16.315	58.897	2.653	0.346
P-129	J-230	J-231	150.0	AC	65.0	23	13.501	0.764	16.642	60.078	2.706	0.354
P-131	J-234	J-105	105.0	PVC	110.0	23	2.632	0.304	1.728	6.237	0.281	0.037
P-139	J-245	J-165	100.0	AC	65.0	24	4.917	0.626	18.476	66.698	3.004	0.393
P-150	J-262	J-263	152.6	PVC	110.0	25	0.764	0.042	0.028	0.102	0.004	0.000

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-151	J-66	J-264	105.0	PVC	110.0	25	11.767	1.359	27.671	99.894	4.499	0.588
P-166	J-285	J-286	105.0	PVC	110.0	26	0.257	0.030	0.023	0.084	0.004	0.000
P-169	J-263	J-291	152.6	PVC	110.0	26	0.258	0.014	0.004	0.014	0.001	0.000
P-174	J-298	J-234	105.0	PVC	110.0	26	0.262	0.030	0.024	0.087	0.004	0.001
P-178	J-74	J-304	105.0	PVC	110.0	27	0.265	0.031	0.024	0.089	0.004	0.001
P-181	J-307	J-142	250.0	CI	70.0	27	0.264	0.006	0.000	0.001	0.000	0.000
P-184	J-312	J-35	105.0	PVC	110.0	30	0.301	0.035	0.031	0.112	0.005	0.001
P-187	J-315	J-316	105.0	PVC	110.0	27	11.626	1.343	27.061	97.690	4.400	0.575
P-199	J-68	J-326	152.6	PVC	110.0	28	40.555	2.217	44.297	159.912	7.202	0.941
P-216	J-106	J-344	105.0	PVC	110.0	29	1.813	0.209	0.866	3.127	0.141	0.019
P-219	J-349	J-350	150.0	AC	65.0	29	0.289	0.016	0.013	0.049	0.002	0.000
P-227	J-359	J-67	200.0	AC	65.0	30	1.543	0.049	0.074	0.266	0.012	0.002
P-229	J-157	J-316	200.0	AC	65.0	30	33.807	1.076	22.435	80.988	3.648	0.477
P-238	J-371	J-359	200.0	AC	65.0	30	0.298	0.009	0.004	0.013	0.001	0.000
P-284	J-40	J-423	150.0	AC	65.0	33	2.704	0.153	0.847	3.057	0.138	0.018
P-285	J-359	J-424	190.8	PVC	110.0	33	0.327	0.011	0.002	0.007	0.000	0.000
P-292	J-36	J-431	105.0	PVC	110.0	36	0.369	0.043	0.045	0.164	0.007	0.001
P-306	J-445	J-446	152.6	PVC	110.0	35	10.733	0.587	3.777	13.637	0.614	0.080
P-310	J-450	J-230	150.0	AC	65.0	35	10.401	0.589	10.266	37.059	1.669	0.218
P-318	J-457	J-245	100.0	AC	65.0	35	7.398	0.942	39.368	142.119	6.401	0.837
P-355	J-505	J-506	105.0	PVC	110.0	37	0.372	0.043	0.046	0.166	0.008	0.001
P-367	J-518	J-519	190.8	PVC	110.0	53	0.528	0.018	0.005	0.017	0.001	0.000
P-368	J-520	J-521	250.0	AC	65.0	38	3.920	0.080	0.140	0.505	0.023	0.003
P-372	J-178	J-51	152.6	PVC	110.0	38	22.909	1.253	15.382	55.531	2.501	0.327

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-374	JIYA MAU 18 LL	J-525	300.0	CI	70.0	38	118.519	1.677	27.702	100.004	4.504	0.589
P-385	J-530	J-531	152.6	PVC	110.0	39	20.081	1.098	12.051	43.505	1.959	0.256
P-390	J-286	J-536	152.6	PVC	110.0	39	29.710	1.624	24.894	89.869	4.048	0.529
P-398	J-36	J-344	105.0	PVC	110.0	40	1.131	0.131	0.361	1.304	0.059	0.008
P-399	J-185	J-67	152.6	PVC	110.0	40	32.977	1.803	30.200	109.021	4.910	0.642
P-427	J-518	J-520	200.0	AC	65.0	43	1.478	0.047	0.068	0.246	0.011	0.002
P-460	J-531	J-84	152.6	PVC	110.0	43	18.814	1.029	10.681	38.558	1.737	0.227
P-475	J-626	J-627	150.0	AC	65.0	44	0.403	0.023	0.025	0.090	0.004	0.001
P-496	J-68	J-27	105.0	PVC	110.0	44	10.741	1.240	23.370	84.365	3.800	0.497
P-501	J-525	J-79	250.0	CI	70.0	45	64.650	1.446	11.910	42.995	1.936	0.253
P-502	J-627	J-134	150.0	AC	65.0	45	0.471	0.027	0.033	0.120	0.005	0.001
P-509	J-39	J-656	150.0	AC	65.0	45	1.780	0.101	0.391	1.409	0.063	0.008
P-517	J-663	J-315	105.0	PVC	110.0	45	7.468	0.862	11.921	43.035	1.938	0.253
P-521	J-665	J-450	150.0	AC	65.0	45	12.103	0.685	13.592	49.065	2.210	0.289
P-542	J-431	J-680	105.0	PVC	110.0	57	0.569	0.066	0.101	0.365	0.017	0.002
P-567	J-445	J-699	190.8	PVC	110.0	48	7.036	0.246	0.582	2.101	0.095	0.012
P-601	J-716	J-663	152.6	PVC	110.0	49	7.162	0.392	1.786	6.447	0.290	0.038
P-612	J-721	J-150	105.0	PVC	110.0	49	0.491	0.057	0.077	0.278	0.013	0.002
P-613	J-722	J-349	150.0	AC	65.0	49	1.069	0.061	0.152	0.549	0.025	0.003
P-614	J-536	J-723	152.6	PVC	110.0	50	26.726	1.461	20.463	73.870	3.327	0.435
P-625	J-726	J-716	152.6	PVC	110.0	50	0.499	0.027	0.013	0.046	0.002	0.000
P-629	J-51	J-457	150.0	AC	65.0	51	14.346	0.812	18.622	67.225	3.028	0.396
P-646	J-723	J-177	152.6	PVC	110.0	52	25.719	1.406	19.057	68.797	3.099	0.405
P-656	J-143	J-185	250.0	CI	70.0	52	4.821	0.108	0.097	0.351	0.016	0.002

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-684	J-264	J-80	105.0	PVC	110.0	57	3.483	0.402	2.904	10.482	0.472	0.062
P-733	J-262	J-781	105.0	PVC	110.0	57	2.155	0.249	1.193	4.308	0.194	0.025
P-748	J-157	J-521	300.0	AC	65.0	58	46.509	0.658	5.620	20.288	0.914	0.120
P-752	J-234	J-786	105.0	PVC	110.0	59	3.973	0.459	3.705	13.374	0.602	0.079
P-766	J-82	J-50	150.0	AC	65.0	60	8.076	0.457	6.426	23.198	1.045	0.137
P-767	J-316	J-83	200.0	AC	65.0	61	21.018	0.669	9.304	33.587	1.513	0.198
P-798	J-699	J-799	105.0	PVC	110.0	64	0.633	0.073	0.123	0.445	0.020	0.003
P-804	J-521	J-525	300.0	AC	65.0	64	52.023	0.736	6.916	24.967	1.124	0.147
P-807	J-446	J-264	152.6	PVC	110.0	65	9.742	0.533	3.157	11.396	0.513	0.067
P-813	J-805	J-786	152.6	PVC	110.0	71	9.019	0.493	2.737	9.880	0.445	0.058
P-830	J-663	J-530	152.6	PVC	110.0	68	13.025	0.712	5.406	19.515	0.879	0.115
P-834	J-812	J-813	152.6	PVC	110.0	67	0.661	0.036	0.022	0.078	0.004	0.000
P-841	J-656	J-818	150.0	AC	65.0	67	0.666	0.038	0.063	0.228	0.010	0.001
P-843	J-83	J-143	200.0	AC	65.0	67	2.751	0.088	0.215	0.777	0.035	0.005
P-844	J-536	J-73	105.0	PVC	110.0	67	1.432	0.165	0.560	2.020	0.091	0.012
P-857	J-315	J-531	100.0	AC	65.0	68	2.763	0.352	6.353	22.935	1.033	0.135
P-863	J-805	J-812	152.6	PVC	110.0	69	5.935	0.325	1.261	4.552	0.205	0.027
P-870	J-231	J-829	150.0	AC	65.0	69	2.694	0.152	0.841	3.036	0.137	0.018
P-884	J-84	J-722	150.0	AC	65.0	72	2.279	0.129	0.617	2.227	0.100	0.013
P-890	J-530	J-286	152.6	PVC	110.0	72	31.331	1.713	27.468	99.158	4.466	0.584
P-897	J-716	J-151	105.0	PVC	110.0	73	9.374	1.083	18.160	65.559	2.953	0.386
P-900	J-178	J-837	152.6	PVC	110.0	77	0.762	0.042	0.028	0.102	0.005	0.000
P-943	J-781	J-845	105.0	PVC	110.0	80	0.795	0.092	0.188	0.679	0.031	0.004
P-948	J-699	J-262	190.8	PVC	110.0	79	4.515	0.158	0.256	0.924	0.042	0.006
P-974	J-851	J-520	200.0	AC	65.0	83	0.823	0.026	0.023	0.083	0.004	0.001

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-997	J-326	J-505	105.0	PVC	110.0	87	1.611	0.186	0.697	2.514	0.113	0.015
P-1028	J-626	J-665	150.0	AC	65.0	95	8.878	0.502	7.656	27.639	1.245	0.163
P-1045	J-786	J-204	152.6	PVC	110.0	105	15.327	0.838	7.307	26.377	1.188	0.155
P-1056	J-431	J-812	152.6	PVC	110.0	104	2.898	0.158	0.334	1.207	0.054	0.007
P-1062	J-326	J-81	152.6	PVC	110.0	106	36.753	2.010	36.916	133.266	6.002	0.785
P-1075	J-79	J-445	190.8	PVC	110.0	111	19.692	0.689	3.915	14.132	0.637	0.083
P-1109	J-204	J-829	105.0	PVC	110.0	129	5.785	0.668	7.430	26.821	1.208	0.158
P-1111	J-874	J-230	105.0	PVC	110.0	127	1.264	0.146	0.444	1.603	0.072	0.009
P-1140	J-829	J-805	152.6	PVC	110.0	142	0.287	0.016	0.005	0.017	0.001	0.000
P-1146	J-82	J-879	105.0	PVC	110.0	147	1.459	0.169	0.579	2.092	0.094	0.012
P-1155	J-165	J-134	105.0	PVC	110.0	153	2.782	0.321	1.915	6.914	0.311	0.041
P-1161	J-50	J-231	152.6	PVC	110.0	164	13.347	0.730	5.656	20.417	0.920	0.120
P-1172	J-457	J-450	105.0	PVC	110.0	181	4.296	0.496	4.282	15.458	0.696	0.091
P-1178	J-245	J-665	105.0	PVC	110.0	188	0.032	0.004	0.000	0.002	0.000	0.000

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1181	J-423	J-626	150.0	AC	65.0	205	5.065	0.287	2.708	9.775	0.440	0.058

Node/ Junction results for Jiya Mau DMA

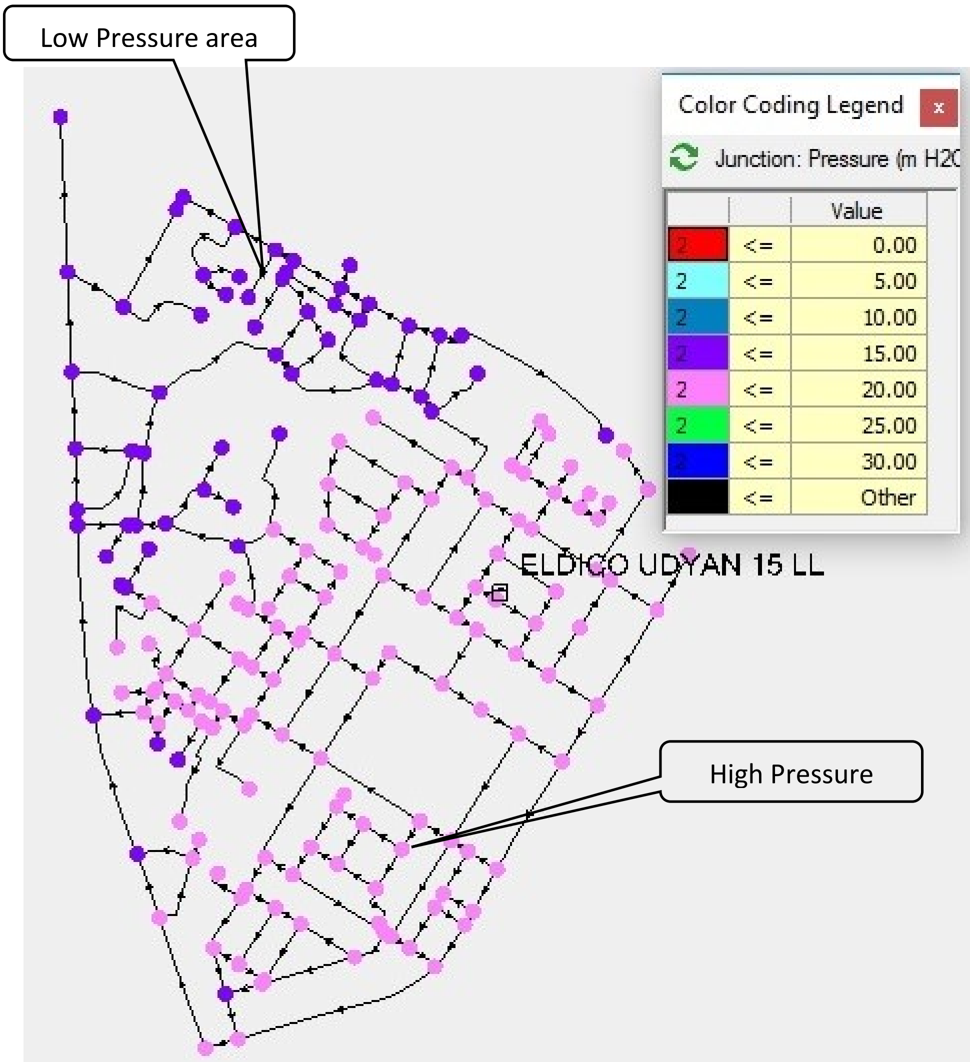
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-26	112.94	0.169	132.00	19.02	10.29	21.82	22.29
J-27	113.00	0.500	131.84	18.80	9.67	21.73	22.23
J-35	114.62	0.372	124.25	9.61	-19.31	18.88	20.45
J-36	114.56	0.827	124.25	9.67	-19.24	18.95	20.52
J-39	111.22	0.523	121.64	10.40	-25.30	21.85	23.79
J-40	111.14	0.401	121.65	10.49	-25.20	21.94	23.87
J-50	113.10	2.320	125.24	12.12	-14.21	20.57	21.99
J-51	113.09	0.973	125.30	12.18	-14.00	20.59	22.01
J-66	112.86	0.357	132.29	19.38	11.40	21.94	22.38
J-67	113.35	0.798	131.10	17.72	6.64	21.27	21.87
J-68	113.40	0.822	130.81	17.37	5.54	21.17	21.81
J-73	113.82	0.785	128.21	14.36	-4.24	20.32	21.33
J-74	113.89	0.382	128.21	14.29	-4.31	20.26	21.27
J-79	112.94	1.672	133.75	20.77	16.60	22.10	22.33
J-80	113.00	0.887	133.14	20.10	14.35	21.95	22.26
J-81	113.09	1.386	125.69	12.57	-12.60	20.65	22.01
J-82	113.05	2.183	125.63	12.56	-12.76	20.68	22.05
J-83	112.17	1.398	132.28	20.07	12.08	22.63	23.07
J-84	112.29	1.279	132.15	19.81	11.47	22.49	22.94
J-105	114.23	0.382	124.31	10.05	-18.70	19.28	20.84
J-106	113.94	0.437	124.29	10.33	-18.48	19.57	21.13
J-134	111.81	2.137	122.23	10.41	-23.76	21.37	23.22
J-135	112.02	0.175	122.23	10.19	-23.97	21.15	23.00
J-142	112.98	0.443	132.30	19.27	11.33	21.83	22.26
J-143	112.76	1.364	132.30	19.50	11.55	22.05	22.48
J-150	112.70	0.676	132.99	20.25	14.10	22.22	22.55
J-151	112.48	1.100	133.00	20.48	14.35	22.44	22.78
J-157	112.25	1.062	133.51	21.22	16.43	22.76	23.01
J-165	113.49	1.944	122.53	9.02	-24.38	19.74	21.55
J-166	113.16	0.191	122.53	9.34	-24.06	20.06	21.87
J-177	113.63	0.709	126.24	12.59	-11.13	20.20	21.48
J-178	113.59	1.338	125.88	12.27	-12.39	20.18	21.52
J-185	113.06	1.117	132.30	19.21	11.27	21.75	22.18
J-204	113.12	2.537	125.33	12.19	-13.90	20.56	21.97
J-230	112.47	1.836	123.94	11.45	-18.29	20.98	22.59
J-231	112.00	2.540	124.31	12.28	-16.46	21.51	23.06
J-234	114.02	1.079	124.35	10.31	-18.35	19.50	21.05
J-245	113.52	2.448	122.96	9.42	-22.85	19.78	21.53

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-262	112.30	1.596	133.27	20.92	15.49	22.66	22.96
J-263	112.53	0.506	133.27	20.69	15.26	22.44	22.73
J-264	112.82	1.458	132.98	20.12	13.94	22.10	22.44
J-285	112.36	0.257	129.22	16.83	0.87	21.95	22.81
J-286	112.83	1.364	129.22	16.36	0.41	21.48	22.34
J-291	112.71	0.258	133.27	20.51	15.08	22.25	22.55
J-298	113.64	0.262	124.35	10.68	-17.97	19.88	21.43
J-304	113.60	0.265	128.21	14.58	-4.03	20.55	21.55
J-307	112.66	0.264	132.30	19.60	11.65	22.15	22.58
J-312	114.09	0.301	124.25	10.14	-18.78	19.41	20.98
J-315	112.05	1.395	132.12	20.02	11.60	22.73	23.18
J-316	112.01	1.162	132.85	20.79	14.27	22.88	23.24
J-326	113.55	2.190	129.59	16.00	0.99	20.82	21.63
J-344	113.61	0.682	124.26	10.63	-18.24	19.89	21.46
J-349	114.00	0.780	132.09	18.06	9.58	20.78	21.24
J-350	113.85	0.289	132.09	18.20	9.72	20.93	21.39
J-359	113.53	0.918	131.10	17.53	6.45	21.09	21.69
J-371	113.42	0.298	131.10	17.64	6.56	21.20	21.80
J-423	110.62	2.361	121.68	11.03	-24.58	22.46	24.39
J-424	113.79	0.327	131.10	17.27	6.19	20.82	21.42
J-431	113.80	1.961	124.25	10.43	-18.48	19.70	21.27
J-445	111.76	1.922	133.31	21.51	16.21	23.22	23.50
J-446	112.51	0.992	133.18	20.64	14.99	22.45	22.75
J-450	112.39	2.595	123.58	11.16	-19.51	21.00	22.66
J-457	113.38	2.651	124.35	10.95	-17.69	20.14	21.70
J-505	113.23	1.240	129.53	16.26	1.09	21.13	21.95
J-506	113.75	0.372	129.52	15.74	0.57	20.61	21.43
J-518	112.23	0.950	133.83	21.56	17.60	22.83	23.04
J-519	112.28	0.528	133.83	21.51	17.55	22.77	22.99
J-520	112.02	1.620	133.84	21.77	17.82	23.04	23.25
J-521	112.10	1.593	133.84	21.70	17.77	22.96	23.18
J-525	112.68	1.846	134.29	21.56	18.79	22.45	22.60
J-530	112.26	1.775	131.21	18.91	8.14	22.37	22.96
J-531	112.48	1.496	131.68	19.16	9.61	22.22	22.74
J-536	113.40	1.552	128.25	14.82	-3.69	20.75	21.75
J-626	111.23	3.410	122.23	10.98	-23.19	21.94	23.79
J-627	111.60	0.874	122.23	10.61	-23.56	21.58	23.43
J-656	111.47	1.114	121.63	10.14	-25.61	21.61	23.54
J-663	112.31	1.605	131.58	19.23	9.40	22.38	22.91

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-665	111.88	3.258	122.96	11.06	-21.21	21.41	23.16
J-680	113.67	0.569	124.25	10.56	-18.36	19.84	21.41
J-699	112.14	1.888	133.29	21.10	15.72	22.82	23.11
J-716	112.90	1.712	131.67	18.73	9.13	21.81	22.33
J-721	113.00	0.491	132.99	19.95	13.79	21.92	22.25
J-722	113.64	1.209	132.10	18.43	9.96	21.14	21.60
J-723	113.79	1.007	127.23	13.41	-7.75	20.20	21.35
J-726	113.00	0.499	131.67	18.63	9.03	21.71	22.23
J-781	113.51	1.360	133.20	19.65	14.04	21.45	21.75
J-786	113.13	2.334	124.57	11.41	-16.67	20.42	21.94
J-799	113.56	0.633	133.28	19.68	14.28	21.41	21.70
J-805	111.63	2.797	124.37	12.72	-15.87	21.90	23.44
J-812	111.40	2.376	124.29	12.86	-15.96	22.11	23.67
J-813	110.20	0.661	124.29	14.06	-14.76	23.30	24.87
J-818	112.12	0.666	121.62	9.49	-26.27	20.96	22.90
J-829	111.01	3.378	124.37	13.34	-15.26	22.51	24.06
J-837	113.78	0.762	125.88	12.08	-12.58	19.99	21.33
J-845	114.05	0.795	133.18	19.10	13.45	20.91	21.21
J-851	112.24	0.823	133.83	21.55	17.60	22.82	23.03
J-874	112.66	1.264	123.88	11.20	-18.68	20.79	22.40
J-879	111.92	1.459	125.55	13.60	-11.94	21.79	23.17

Eldico DMA

In case of Eldico DMA, the total flow through this DMA is 1.47 MLD. This demand is applied to that DMA. As the supply for this DMA is for 5 hours, the peak factor is 4.8.



The results of calibration are presented in table below:

Pipe results for Eldico DMA

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-11	J-16	J-17	100.0	AC	65.0	5	0.659	0.084	0.447	2.751	0.186	0.024
P-12	J-18	J-19	80.0	AC	65.0	5	0.537	0.107	0.906	5.580	0.382	0.049
P-20	J-33	J-34	80.0	AC	65.0	7	0.020	0.004	0.003	0.014	0.001	0.000
P-26	J-45	J-46	105.0	PVC	110.0	8	0.222	0.026	0.018	0.109	0.008	0.001
P-28	ELDICO UDYAN 15 LL	J-49	250.0	CI	70.0	9	81.667	1.826	18.359	112.913	7.688	1.005
P-30	J-52	J-53	152.6	PVC	110.0	9	0.959	0.052	0.043	0.266	0.018	0.002
P-31	J-54	J-55	100.0	AC	65.0	10	0.334	0.042	0.126	0.779	0.054	0.007
P-39	J-69	J-70	100.0	AC	65.0	11	1.952	0.249	3.339	20.535	1.398	0.183
P-40	J-71	J-72	100.0	AC	65.0	11	4.952	0.631	18.720	115.133	7.840	1.024
P-50	J-91	J-92	80.0	AC	65.0	14	0.042	0.008	0.008	0.048	0.003	0.000
P-54	J-99	J-100	152.6	PVC	110.0	15	1.642	0.090	0.116	0.718	0.049	0.006
P-55	J-101	J-102	105.0	PVC	110.0	15	5.217	0.602	6.135	37.731	2.570	0.336
P-59	J-107	J-108	46.6	PVC	110.0	15	0.367	0.215	2.350	14.449	0.984	0.128
P-63	J-114	J-115	80.0	AC	65.0	16	3.279	0.652	25.862	159.061	10.830	1.415
P-65	J-118	J-119	46.6	PVC	110.0	16	0.427	0.250	3.109	19.125	1.302	0.170
P-69	J-126	J-127	152.6	PVC	110.0	17	0.050	0.003	0.000	0.001	0.000	0.000
P-71	J-130	J-131	152.6	PVC	110.0	17	0.051	0.003	0.001	0.001	0.000	0.000
P-74	J-46	J-136	105.0	PVC	110.0	18	0.333	0.038	0.037	0.231	0.016	0.002
P-81	J-148	J-149	80.0	AC	65.0	18	3.144	0.625	23.924	147.141	10.019	1.310
P-84	J-153	J-154	190.8	PVC	110.0	19	8.526	0.298	0.831	5.109	0.348	0.046
P-85	J-155	J-156	150.0	AC	65.0	19	1.086	0.061	0.156	0.961	0.065	0.008

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-87	J-115	J-158	80.0	AC	65.0	19	2.992	0.595	21.825	134.228	9.139	1.195
P-88	J-159	J-160	105.0	PVC	110.0	19	3.320	0.383	2.657	16.341	1.113	0.146
P-89	J-161	J-162	150.0	AC	65.0	19	4.026	0.228	1.770	10.889	0.742	0.097
P-90	J-163	J-164	200.0	AC	65.0	19	8.778	0.279	1.846	11.357	0.773	0.101
P-96	J-175	J-176	80.0	AC	65.0	20	1.472	0.293	5.871	36.111	2.459	0.321
P-99	J-181	J-182	46.6	PVC	110.0	20	0.060	0.035	0.081	0.498	0.034	0.004
P-105	J-192	J-193	150.0	AC	65.0	21	2.789	0.158	0.897	5.518	0.376	0.049
P-108	J-198	J-18	80.0	AC	65.0	21	0.481	0.096	0.740	4.552	0.310	0.041
P-110	J-200	J-201	105.0	PVC	110.0	21	0.075	0.009	0.003	0.014	0.001	0.000
P-115	J-175	J-114	80.0	AC	65.0	22	1.597	0.318	6.822	41.958	2.857	0.374
P-116	J-208	J-209	105.0	PVC	110.0	23	10.139	1.171	21.002	129.168	8.795	1.150
P-123	J-219	J-220	105.0	PVC	110.0	22	0.369	0.043	0.045	0.279	0.019	0.003
P-126	J-225	J-226	105.0	PVC	110.0	23	0.712	0.082	0.153	0.944	0.064	0.008
P-132	J-235	J-236	105.0	PVC	110.0	23	5.704	0.659	7.237	44.509	3.031	0.396
P-138	J-243	J-244	46.6	PVC	110.0	23	0.069	0.041	0.107	0.656	0.045	0.006
P-140	J-108	J-158	46.6	PVC	110.0	24	1.237	0.725	22.330	137.333	9.351	1.223

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-142	J-248	J-249	100.0	AC	65.0	24	0.070	0.009	0.007	0.044	0.003	0.000
P-143	J-250	J-225	105.0	PVC	110.0	24	0.071	0.008	0.002	0.014	0.001	0.000
P-145	J-253	J-254	190.8	PVC	110.0	24	2.493	0.087	0.085	0.524	0.036	0.005
P-158	J-274	J-136	152.6	PVC	110.0	25	2.386	0.130	0.233	1.435	0.098	0.013
P-160	J-243	J-181	46.6	PVC	110.0	25	0.214	0.125	0.863	5.305	0.361	0.047
P-171	J-293	J-294	152.6	PVC	110.0	32	1.386	0.076	0.085	0.525	0.036	0.005
P-176	J-53	J-301	152.6	PVC	110.0	26	2.217	0.121	0.204	1.252	0.085	0.011
P-179	J-176	J-18	80.0	AC	65.0	27	0.213	0.042	0.164	1.010	0.069	0.009
P-195	J-19	J-226	80.0	AC	65.0	28	0.211	0.042	0.161	0.990	0.067	0.009
P-197	J-324	J-49	250.0	CI	70.0	27	47.160	1.055	6.641	40.842	2.781	0.363
P-207	J-335	J-336	190.8	PVC	110.0	28	12.022	0.420	1.570	9.653	0.657	0.086
P-220	J-200	J-351	152.6	PVC	110.0	29	0.087	0.005	0.001	0.003	0.000	0.000
P-224	J-71	J-355	80.0	AC	65.0	29	3.832	0.762	34.520	212.310	14.456	1.890
P-234	J-149	J-366	80.0	AC	65.0	30	3.703	0.737	32.406	199.305	13.570	1.774

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-239	J-372	J-373	105.0	PVC	110.0	31	0.223	0.026	0.018	0.110	0.007	0.001
P-247	J-158	J-101	80.0	AC	65.0	31	4.446	0.885	45.458	279.579	19.036	2.488
P-296	J-236	J-435	105.0	PVC	110.0	35	5.850	0.676	7.585	46.650	3.176	0.415
P-297	J-225	J-176	105.0	PVC	110.0	34	1.022	0.118	0.300	1.842	0.125	0.017
P-314	J-201	J-220	105.0	PVC	110.0	35	1.137	0.131	0.365	2.244	0.153	0.020
P-321	J-181	J-461	46.6	PVC	110.0	35	0.513	0.301	4.370	26.881	1.830	0.239
P-323	J-55	J-462	100.0	AC	65.0	37	0.397	0.051	0.174	1.074	0.073	0.010
P-327	J-467	J-468	105.0	PVC	110.0	38	0.114	0.013	0.005	0.032	0.002	0.000
P-328	J-469	J-470	100.0	AC	65.0	36	0.186	0.024	0.043	0.264	0.018	0.002
P-331	J-475	J-476	100.0	AC	65.0	36	0.387	0.049	0.167	1.027	0.070	0.009
P-332	J-476	J-17	100.0	AC	65.0	36	0.094	0.012	0.012	0.074	0.005	0.001
P-333	J-34	J-477	80.0	AC	65.0	36	0.469	0.093	0.705	4.338	0.295	0.039
P-335	J-480	J-481	46.6	PVC	110.0	36	0.384	0.225	2.562	15.754	1.073	0.140
P-343	J-461	J-487	105.0	PVC	110.0	36	0.108	0.012	0.005	0.028	0.002	0.000

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-351	J-498	J-499	150.0	AC	65.0	37	8.483	0.480	7.038	43.286	2.947	0.385
P-354	J-503	J-504	46.6	PVC	110.0	37	0.390	0.229	2.637	16.218	1.104	0.144
P-357	J-507	J-508	190.8	PVC	110.0	37	2.663	0.093	0.096	0.592	0.040	0.005
P-360	J-511	J-512	152.6	PVC	110.0	37	2.393	0.131	0.234	1.442	0.098	0.013
P-362	J-301	J-514	152.6	PVC	110.0	38	5.260	0.288	1.008	6.200	0.422	0.055
P-363	J-160	J-208	105.0	PVC	110.0	38	5.539	0.640	6.855	42.158	2.871	0.375
P-370	J-130	J-523	152.6	PVC	110.0	38	2.036	0.111	0.174	1.069	0.073	0.010
P-375	J-526	J-19	105.0	PVC	110.0	39	0.114	0.013	0.005	0.032	0.002	0.000
P-382	J-200	J-219	152.6	PVC	110.0	39	2.996	0.164	0.355	2.186	0.149	0.019
P-388	J-533	J-293	152.6	PVC	110.0	39	2.365	0.129	0.229	1.411	0.096	0.013
P-391	J-537	J-511	152.6	PVC	110.0	39	3.650	0.200	0.512	3.152	0.215	0.028
P-394	J-538	J-537	152.6	PVC	110.0	39	0.079	0.004	0.000	0.003	0.000	0.000
P-400	J-542	J-543	152.6	PVC	110.0	40	6.438	0.352	1.466	9.015	0.614	0.080
P-404	J-547	J-548	105.0	PVC	110.0	40	0.119	0.014	0.006	0.034	0.002	0.000

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-407	J-69	J-553	100.0	AC	65.0	51	0.150	0.019	0.029	0.178	0.012	0.001
P-408	J-254	J-554	190.8	PVC	110.0	41	6.852	0.240	0.554	3.408	0.232	0.030
P-409	J-555	J-556	200.0	AC	65.0	41	14.202	0.452	4.502	27.687	1.885	0.246
P-413	J-70	J-469	100.0	AC	65.0	41	1.585	0.202	2.269	13.956	0.950	0.124
P-416	J-355	J-91	80.0	AC	65.0	41	3.707	0.738	32.469	199.691	13.597	1.778
P-418	J-564	J-565	152.6	PVC	110.0	58	0.171	0.009	0.002	0.011	0.001	0.000
P-419	J-198	J-566	105.0	PVC	110.0	54	0.160	0.018	0.010	0.060	0.004	0.001
P-422	J-568	J-569	105.0	PVC	110.0	42	0.263	0.030	0.024	0.149	0.010	0.001
P-431	J-163	J-161	150.0	AC	65.0	42	0.274	0.015	0.012	0.075	0.005	0.001
P-435	J-164	J-162	150.0	AC	65.0	42	0.388	0.022	0.023	0.143	0.010	0.001
P-463	J-468	J-610	105.0	PVC	110.0	45	0.135	0.016	0.007	0.043	0.003	0.000
P-467	J-324	J-336	250.0	CI	70.0	43	39.756	0.889	4.840	29.767	2.027	0.265
P-477	J-629	J-630	250.0	CI	70.0	44	35.199	0.787	3.863	23.758	1.618	0.211
P-489	J-543	J-253	190.8	PVC	110.0	44	9.495	0.332	1.014	6.237	0.425	0.056

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-492	J-461	J-118	46.6	PVC	110.0	44	0.937	0.549	13.347	82.087	5.589	0.731
P-503	J-102	J-649	152.6	PVC	110.0	45	8.809	0.482	2.620	16.112	1.097	0.143
P-512	J-507	J-235	190.8	PVC	110.0	45	6.566	0.230	0.512	3.150	0.214	0.028
P-514	J-659	J-72	105.0	PVC	110.0	45	6.972	0.805	10.498	64.566	4.396	0.575
P-518	J-70	J-538	100.0	AC	65.0	45	3.826	0.487	11.605	71.376	4.860	0.635
P-520	J-664	J-16	100.0	AC	65.0	45	1.501	0.191	2.053	12.627	0.860	0.113
P-522	J-126	J-666	190.8	PVC	110.0	45	0.643	0.022	0.007	0.043	0.003	0.000
P-524	J-668	J-54	80.0	AC	65.0	46	0.135	0.027	0.070	0.432	0.029	0.004
P-528	J-671	J-629	250.0	CI	70.0	46	1.422	0.032	0.010	0.062	0.004	0.001
P-532	J-198	J-114	80.0	AC	65.0	46	1.433	0.285	5.582	34.330	2.338	0.306
P-536	J-435	J-155	150.0	AC	65.0	46	3.307	0.187	1.230	7.563	0.515	0.067
P-541	J-679	J-503	46.6	PVC	110.0	46	0.137	0.080	0.379	2.332	0.159	0.021
P-543	J-681	J-52	100.0	AC	65.0	50	3.355	0.427	9.104	55.990	3.812	0.498
P-544	J-504	J-682	46.6	PVC	110.0	46	0.137	0.081	0.382	2.347	0.160	0.021

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-545	J-336	J-683	190.8	PVC	110.0	47	27.385	0.958	7.210	44.345	3.019	0.395
P-546	J-684	J-630	190.8	PVC	110.0	47	24.621	0.861	5.921	36.415	2.479	0.324
P-553	J-666	J-508	190.8	PVC	110.0	47	1.491	0.052	0.033	0.203	0.014	0.002
P-561	J-155	J-694	100.0	AC	65.0	47	4.725	0.602	17.159	105.535	7.186	0.939
P-563	J-694	J-324	250.0	AC	65.0	47	7.055	0.144	0.415	2.555	0.174	0.023
P-569	J-481	J-504	46.6	PVC	110.0	48	0.136	0.080	0.375	2.305	0.157	0.020
P-582	J-705	J-706	152.6	PVC	110.0	48	0.033	0.002	0.000	0.001	0.000	0.000
P-606	J-503	J-480	105.0	PVC	110.0	49	0.920	0.106	0.247	1.518	0.103	0.013
P-610	J-102	J-366	100.0	AC	65.0	49	3.270	0.416	8.677	53.368	3.634	0.475
P-616	J-45	J-568	105.0	PVC	110.0	53	0.353	0.041	0.042	0.257	0.017	0.002
P-618	J-72	J-480	105.0	PVC	110.0	50	1.705	0.197	0.774	4.758	0.324	0.042
P-627	J-706	J-126	152.6	PVC	110.0	50	0.260	0.014	0.004	0.024	0.002	0.000
P-639	J-156	J-461	105.0	PVC	110.0	51	2.053	0.237	1.090	6.706	0.457	0.060
P-660	J-748	J-705	152.6	PVC	110.0	53	0.212	0.012	0.003	0.016	0.001	0.000

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-670	J-753	J-754	200.0	AC	65.0	53	11.952	0.380	3.271	20.116	1.370	0.179
P-680	J-219	J-533	152.6	PVC	110.0	54	3.706	0.203	0.527	3.242	0.221	0.029
P-682	J-649	J-761	152.6	PVC	110.0	54	2.886	0.158	0.332	2.040	0.139	0.018
P-687	J-762	J-107	46.6	PVC	110.0	54	0.161	0.094	0.509	3.134	0.213	0.028
P-689	J-659	J-498	190.8	PVC	110.0	54	1.626	0.057	0.039	0.237	0.016	0.002
P-690	J-34	J-764	80.0	AC	65.0	54	0.161	0.032	0.097	0.599	0.041	0.005
P-692	J-547	J-765	105.0	PVC	110.0	56	0.165	0.019	0.010	0.063	0.004	0.001
P-694	J-630	J-335	190.8	PVC	110.0	55	10.148	0.355	1.147	7.054	0.480	0.063
P-695	J-767	J-768	152.6	PVC	110.0	55	0.163	0.009	0.002	0.010	0.001	0.000
P-696	J-512	J-564	152.6	PVC	110.0	55	2.079	0.114	0.181	1.112	0.076	0.010
P-698	J-523	J-542	152.6	PVC	110.0	55	3.236	0.177	0.410	2.522	0.172	0.022
P-701	J-769	J-274	152.6	PVC	110.0	55	1.759	0.096	0.133	0.816	0.056	0.007
P-703	J-49	J-629	250.0	CI	70.0	55	34.206	0.765	3.664	22.532	1.534	0.201
P-704	J-770	J-753	152.6	PVC	110.0	56	12.275	0.671	4.843	29.787	2.028	0.265

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-705	J-683	J-771	190.8	PVC	110.0	56	23.474	0.821	5.420	33.335	2.270	0.297
P-708	J-118	J-772	46.6	PVC	110.0	56	0.166	0.097	0.539	3.313	0.226	0.029
P-710	J-366	J-71	100.0	AC	65.0	56	0.834	0.106	0.692	4.254	0.290	0.038
P-713	J-556	J-664	100.0	AC	65.0	56	2.340	0.298	4.672	28.732	1.956	0.256
P-715	J-355	J-149	80.0	AC	65.0	56	0.251	0.050	0.221	1.361	0.093	0.012
P-721	J-664	J-475	100.0	AC	65.0	56	1.307	0.166	1.587	9.761	0.665	0.087
P-723	J-564	J-542	152.6	PVC	110.0	56	2.753	0.151	0.304	1.869	0.127	0.017
P-728	J-512	J-523	150.0	AC	65.0	57	0.756	0.043	0.080	0.492	0.034	0.004
P-732	J-511	J-130	152.6	PVC	110.0	57	1.653	0.090	0.118	0.727	0.049	0.006
P-735	J-301	J-161	150.0	AC	65.0	57	3.403	0.193	1.297	7.976	0.543	0.071
P-742	J-164	J-554	200.0	AC	65.0	58	9.518	0.303	2.145	13.194	0.898	0.117
P-753	J-162	J-254	150.0	AC	65.0	59	3.994	0.226	1.744	10.725	0.730	0.095
P-761	J-788	J-226	105.0	PVC	110.0	60	0.596	0.069	0.111	0.680	0.046	0.006
P-762	J-569	J-373	105.0	PVC	110.0	61	0.569	0.066	0.101	0.622	0.042	0.006

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-764	J-153	J-54	100.0	AC	65.0	60	0.810	0.103	0.655	4.030	0.274	0.036
P-770	J-477	J-789	80.0	AC	65.0	61	1.390	0.277	5.281	32.480	2.212	0.289
P-773	J-514	J-163	200.0	AC	65.0	62	8.688	0.277	1.812	11.143	0.759	0.099
P-774	J-462	J-547	105.0	PVC	110.0	67	0.767	0.089	0.176	1.082	0.074	0.010
P-775	J-789	J-198	105.0	PVC	110.0	62	0.249	0.029	0.022	0.135	0.009	0.001
P-778	J-754	J-791	200.0	AC	65.0	62	0.571	0.018	0.012	0.072	0.005	0.001
P-792	J-115	J-148	80.0	AC	65.0	63	0.579	0.115	1.043	6.414	0.437	0.057
P-793	J-789	J-148	80.0	AC	65.0	64	2.135	0.425	11.680	71.833	4.891	0.639
P-797	J-372	J-568	105.0	PVC	110.0	66	0.568	0.066	0.101	0.621	0.042	0.006
P-799	J-119	J-800	46.6	PVC	110.0	64	0.189	0.111	0.689	4.237	0.289	0.038
P-814	J-136	J-200	152.6	PVC	110.0	65	2.375	0.130	0.231	1.422	0.097	0.013
P-815	J-806	J-274	105.0	PVC	110.0	66	0.194	0.022	0.014	0.085	0.006	0.001
P-820	J-808	J-45	105.0	PVC	110.0	66	0.196	0.023	0.014	0.087	0.006	0.001
P-825	J-193	J-809	150.0	AC	65.0	66	0.930	0.053	0.117	0.722	0.049	0.006

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-833	J-811	J-248	100.0	AC	65.0	68	0.868	0.111	0.744	4.576	0.312	0.041
P-839	J-477	J-817	105.0	PVC	110.0	107	0.317	0.037	0.034	0.211	0.014	0.002
P-849	J-822	J-99	152.6	PVC	110.0	68	0.219	0.012	0.003	0.017	0.001	0.000
P-851	J-823	J-193	100.0	AC	65.0	68	2.320	0.295	4.595	28.262	1.924	0.251
P-852	J-684	J-823	200.0	AC	65.0	68	2.722	0.087	0.211	1.299	0.088	0.012
P-856	J-826	J-684	190.8	PVC	110.0	68	21.357	0.747	4.550	27.981	1.905	0.249
P-859	J-468	J-769	105.0	PVC	110.0	113	0.832	0.096	0.205	1.258	0.086	0.011
P-874	J-201	J-46	105.0	PVC	110.0	70	0.838	0.097	0.207	1.275	0.087	0.011
P-876	J-475	J-69	100.0	AC	65.0	72	1.406	0.179	1.817	11.176	0.761	0.099
P-880	J-209	J-833	105.0	PVC	110.0	75	0.221	0.026	0.018	0.108	0.007	0.001
P-888	J-836	J-769	152.6	PVC	110.0	72	0.214	0.012	0.003	0.016	0.001	0.000
P-895	J-160	J-533	105.0	PVC	110.0	73	1.833	0.212	0.884	5.436	0.370	0.048
P-899	J-154	J-822	190.8	PVC	110.0	73	5.491	0.192	0.368	2.262	0.154	0.020
P-905	J-499	J-770	150.0	AC	65.0	74	8.811	0.499	7.550	46.437	3.162	0.413

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-909	J-159	J-220	105.0	PVC	110.0	100	1.234	0.143	0.425	2.614	0.178	0.023
P-910	J-789	J-838	105.0	PVC	110.0	74	0.220	0.025	0.017	0.107	0.007	0.001
P-915	J-839	J-100	105.0	PVC	110.0	75	1.451	0.168	0.574	3.527	0.240	0.031
P-919	J-809	J-841	190.8	PVC	110.0	76	0.224	0.008	0.001	0.006	0.000	0.000
P-920	J-470	J-681	100.0	AC	65.0	76	1.308	0.167	1.590	9.777	0.666	0.087
P-923	J-705	J-666	152.6	PVC	110.0	76	0.348	0.019	0.007	0.041	0.003	0.000
P-931	J-843	J-91	105.0	PVC	110.0	83	3.256	0.376	2.563	15.764	1.073	0.140
P-933	J-844	J-101	105.0	PVC	110.0	107	0.318	0.037	0.034	0.212	0.014	0.002
P-936	J-208	J-293	105.0	PVC	110.0	77	4.191	0.484	4.090	25.154	1.713	0.224
P-938	J-770	J-335	190.8	PVC	110.0	77	21.697	0.759	4.685	28.814	1.962	0.256
P-947	J-846	J-847	105.0	PVC	110.0	79	1.689	0.195	0.760	4.672	0.318	0.042
P-950	J-791	J-826	190.8	PVC	110.0	79	18.542	0.649	3.502	21.538	1.466	0.192
P-959	J-470	J-17	100.0	AC	65.0	80	0.924	0.118	0.836	5.143	0.350	0.046
P-960	J-476	J-469	100.0	AC	65.0	81	0.932	0.119	0.849	5.223	0.356	0.046

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-962	J-850	J-811	200.0	AC	65.0	81	11.113	0.354	2.858	17.577	1.197	0.156
P-964	J-850	J-248	100.0	AC	65.0	90	1.478	0.188	1.994	12.264	0.835	0.109
P-976	J-694	J-671	250.0	CI	70.0	83	1.803	0.040	0.016	0.097	0.007	0.001
P-995	J-100	J-55	105.0	PVC	110.0	87	0.334	0.039	0.038	0.233	0.016	0.002
P-1009	J-209	J-236	105.0	PVC	110.0	124	11.016	1.272	24.492	150.633	10.256	1.341
P-1012	J-462	J-843	100.0	AC	65.0	92	1.743	0.222	2.705	16.638	1.133	0.148
P-1013	J-156	J-192	150.0	AC	65.0	91	1.445	0.082	0.265	1.632	0.111	0.014
P-1017	J-822	J-857	190.8	PVC	110.0	92	5.018	0.176	0.311	1.914	0.130	0.017
P-1021	J-508	J-748	152.6	PVC	110.0	93	0.646	0.035	0.020	0.127	0.009	0.001
P-1022	J-847	J-858	105.0	PVC	110.0	112	0.333	0.038	0.038	0.231	0.016	0.002
P-1037	J-154	J-99	152.6	PVC	110.0	111	2.433	0.133	0.242	1.487	0.101	0.013
P-1048	J-373	J-159	105.0	PVC	110.0	113	1.397	0.161	0.535	3.289	0.224	0.029
P-1068	J-839	J-857	105.0	PVC	110.0	109	0.692	0.080	0.145	0.895	0.061	0.008
P-1069	J-771	J-507	190.8	PVC	110.0	108	9.794	0.343	1.074	6.604	0.450	0.059

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1072	J-659	J-771	152.6	PVC	110.0	111	12.867	0.704	5.285	32.503	2.213	0.289
P-1076	J-868	J-235	105.0	PVC	110.0	111	0.330	0.038	0.037	0.228	0.016	0.002
P-1082	J-761	J-498	152.6	PVC	110.0	114	6.247	0.342	1.386	8.527	0.581	0.076
P-1084	J-649	J-659	152.6	PVC	110.0	115	6.556	0.358	1.516	9.324	0.635	0.083
P-1086	J-16	J-681	100.0	AC	65.0	115	1.333	0.170	1.646	10.124	0.689	0.090
P-1087	J-192	J-767	152.6	PVC	110.0	116	0.669	0.037	0.022	0.136	0.009	0.001
P-1091	J-870	J-108	46.6	PVC	110.0	127	0.378	0.221	2.480	15.250	1.038	0.136
P-1093	J-857	J-846	190.8	PVC	110.0	119	3.378	0.118	0.149	0.920	0.063	0.008
P-1115	J-537	J-52	152.6	PVC	110.0	129	2.955	0.162	0.346	2.131	0.145	0.019
P-1121	J-875	J-847	105.0	PVC	110.0	133	0.394	0.045	0.051	0.315	0.021	0.003
P-1124	J-538	J-761	152.6	PVC	110.0	142	4.418	0.242	0.730	4.488	0.306	0.040
P-1125	J-826	J-809	190.8	PVC	110.0	135	1.976	0.069	0.055	0.341	0.023	0.003
P-1127	J-53	J-253	150.0	AC	65.0	135	3.684	0.208	1.501	9.235	0.629	0.082
P-1132	J-683	J-435	105.0	PVC	110.0	139	3.195	0.369	2.474	15.215	1.036	0.135

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1137	J-761	J-543	190.8	PVC	110.0	141	2.392	0.084	0.079	0.485	0.033	0.004
P-1142	J-843	J-878	105.0	PVC	110.0	168	0.498	0.057	0.079	0.486	0.033	0.004
P-1148	J-839	J-372	105.0	PVC	110.0	163	1.114	0.129	0.352	2.163	0.147	0.019
P-1150	J-554	J-791	190.8	PVC	110.0	150	17.107	0.598	3.017	18.553	1.263	0.165
P-1152	J-253	J-754	200.0	AC	65.0	151	11.736	0.374	3.162	19.445	1.324	0.173
P-1165	J-555	J-850	200.0	AC	65.0	166	13.589	0.433	4.148	25.514	1.737	0.227
P-1169	J-811	J-788	200.0	AC	65.0	174	11.023	0.351	2.815	17.315	1.179	0.154
P-1177	J-846	J-882	190.8	PVC	110.0	186	0.551	0.019	0.005	0.032	0.002	0.000
P-1183	J-294	J-883	190.8	PVC	110.0	218	0.646	0.023	0.007	0.043	0.003	0.000
P-1186	J-788	J-153	200.0	AC	65.0	228	10.247	0.326	2.460	15.127	1.030	0.135
P-1191	J-556	J-514	200.0	AC	65.0	254	12.900	0.411	3.767	23.170	1.578	0.206

Node/ Junction results for Eldico DMA

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-16	123.90	0.490	140.47	16.54	2.50	18.12	19.11
J-17	123.82	0.359	140.47	16.62	2.59	18.20	19.19
J-18	122.11	0.157	138.54	16.40	-7.57	19.10	20.80
J-19	122.23	0.212	138.53	16.27	-7.71	18.98	20.68
J-33	124.55	0.020	138.20	13.63	-12.05	16.53	18.34
J-34	124.51	0.288	138.20	13.67	-12.00	16.57	18.38
J-45	124.88	0.379	137.81	12.90	-14.82	16.03	17.99
J-46	124.88	0.283	137.81	12.90	-14.82	16.03	17.99
J-49	124.29	0.300	143.03	18.70	17.83	18.80	18.86
J-52	123.44	0.558	141.11	17.64	6.92	18.85	19.61
J-53	123.77	0.508	141.11	17.30	6.58	18.52	19.27
J-54	125.97	0.342	137.92	11.93	-15.21	14.99	16.91
J-55	125.89	0.396	137.92	12.00	-15.14	15.07	16.98
J-69	122.77	0.396	140.60	17.79	4.41	19.30	20.25
J-70	122.85	0.288	140.63	17.75	4.56	19.24	20.17
J-71	123.00	0.286	140.74	17.70	5.04	19.13	20.02
J-72	123.00	0.315	140.94	17.91	6.31	19.22	20.04
J-91	122.57	0.409	138.39	15.78	-8.96	18.57	20.32
J-92	122.41	0.042	138.39	15.95	-8.79	18.74	20.49
J-99	126.29	0.573	137.92	11.60	-15.55	14.67	16.58
J-100	126.82	0.525	137.92	11.08	-16.08	14.14	16.06
J-101	123.01	0.453	141.04	17.99	6.87	19.25	20.03
J-102	122.96	0.322	141.13	18.13	7.48	19.33	20.09
J-107	122.94	0.206	139.08	16.11	-5.04	18.50	19.99
J-108	123.07	0.493	139.12	16.01	-4.95	18.38	19.86
J-114	122.29	0.249	138.81	16.48	-6.08	19.03	20.63
J-115	122.56	0.292	139.23	16.63	-3.78	18.94	20.38
J-118	124.37	0.345	141.37	16.97	7.56	18.03	18.69
J-119	124.44	0.238	141.32	16.85	7.18	17.94	18.62
J-126	123.63	0.333	141.88	18.22	11.45	18.98	19.46
J-127	123.64	0.050	141.88	18.20	11.43	18.97	19.45
J-130	124.90	0.332	141.19	16.25	5.89	17.42	18.15
J-131	124.75	0.051	141.19	16.40	6.04	17.57	18.30
J-136	124.94	0.321	137.81	12.84	-14.88	15.97	17.93
J-148	122.53	0.430	139.29	16.73	-3.34	18.99	20.41
J-149	122.80	0.309	139.73	16.90	-0.92	18.91	20.17
J-153	125.21	0.911	137.96	12.72	-14.21	15.76	17.66
J-154	124.92	0.602	137.94	12.99	-14.02	16.04	17.95

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-155	124.63	0.332	142.02	17.35	11.27	18.04	18.47
J-156	124.85	0.478	142.01	17.13	11.03	17.82	18.25
J-158	122.81	0.217	139.65	16.81	-1.46	18.87	20.16
J-159	125.91	0.689	137.88	11.94	-15.42	15.03	16.97
J-160	125.80	0.386	137.93	12.10	-14.99	15.16	17.08
J-161	122.64	0.350	141.18	18.50	8.13	19.67	20.41
J-162	122.77	0.355	141.22	18.41	8.22	19.56	20.28
J-163	122.40	0.363	141.18	18.75	8.38	19.92	20.65
J-164	122.22	0.352	141.22	18.96	8.77	20.11	20.83
J-175	122.68	0.124	138.66	15.95	-7.39	18.58	20.23
J-176	122.47	0.237	138.54	16.04	-7.90	18.75	20.44
J-181	124.82	0.240	141.80	16.95	9.77	17.76	18.27
J-182	125.18	0.060	141.80	16.59	9.40	17.40	17.91
J-192	124.00	0.676	142.04	18.00	12.03	18.68	19.10
J-193	124.00	0.460	142.06	18.02	12.14	18.68	19.09
J-198	122.03	0.542	138.55	16.49	-7.39	19.18	20.87
J-200	125.39	0.459	137.82	12.40	-15.24	15.52	17.48
J-201	125.13	0.374	137.82	12.67	-14.97	15.79	17.74
J-208	125.99	0.409	138.19	12.18	-13.58	15.09	16.91
J-209	125.79	0.656	138.67	12.85	-10.45	15.48	17.12
J-219	126.06	0.341	137.84	11.75	-15.82	14.86	16.81
J-220	125.84	0.467	137.83	11.97	-15.61	15.08	17.03
J-225	123.26	0.238	138.53	15.24	-8.75	17.95	19.64
J-226	122.96	0.327	138.53	15.54	-8.47	18.25	19.94
J-235	124.56	0.532	141.86	17.27	10.40	18.04	18.53
J-236	124.66	0.537	141.70	17.00	9.28	17.87	18.42
J-243	124.55	0.144	141.78	17.20	9.91	18.02	18.54
J-244	125.11	0.069	141.78	16.63	9.33	17.46	17.97
J-248	122.79	0.540	139.06	16.24	-5.03	18.63	20.14
J-249	123.00	0.070	139.06	16.03	-5.24	18.43	19.93
J-250	123.92	0.071	138.53	14.58	-9.41	17.29	18.99
J-253	123.71	1.050	141.32	17.57	7.90	18.66	19.35
J-254	123.68	0.365	141.32	17.60	7.93	18.69	19.37
J-274	124.58	0.433	137.80	13.19	-14.56	16.32	18.28
J-293	126.75	0.439	137.87	11.10	-16.28	14.19	16.13
J-294	126.87	0.740	137.87	10.98	-16.42	14.07	16.01
J-301	124.43	0.360	141.11	16.65	5.90	17.86	18.62
J-324	124.64	0.349	142.85	18.18	16.37	18.38	18.51
J-335	124.85	0.473	142.60	17.71	14.61	18.06	18.28

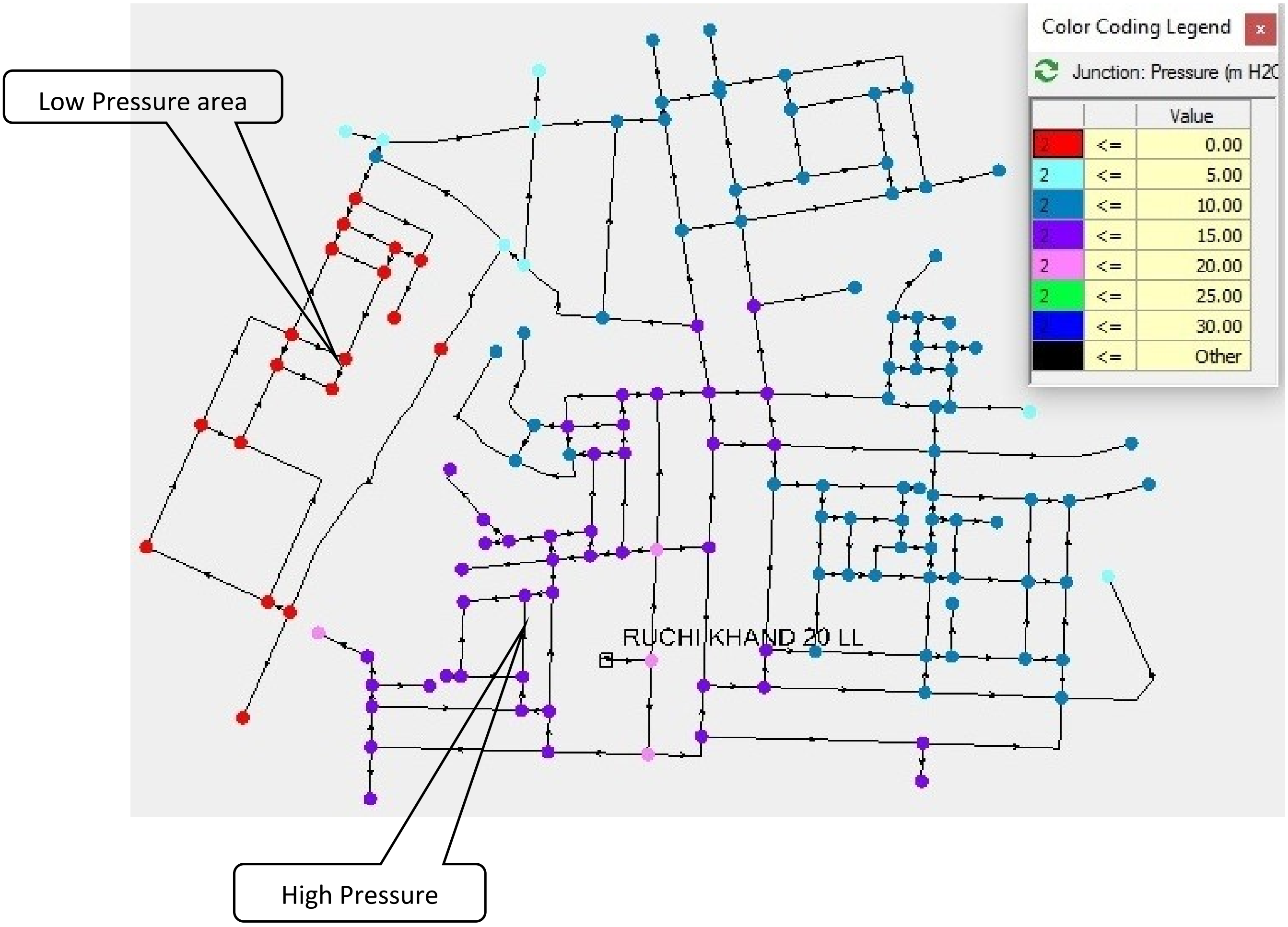
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-336	124.95	0.349	142.64	17.65	14.78	17.98	18.18
J-351	125.95	0.087	137.82	11.85	-15.80	14.97	16.92
J-355	123.00	0.375	139.72	16.69	-1.19	18.71	19.97
J-366	123.00	0.401	140.70	17.66	4.80	19.11	20.02
J-372	126.29	0.769	137.82	11.50	-16.18	14.62	16.58
J-373	126.53	0.606	137.82	11.26	-16.41	14.38	16.34
J-435	124.45	0.652	141.96	17.47	11.10	18.19	18.64
J-461	124.71	0.495	141.96	17.22	10.83	17.94	18.39
J-462	125.64	0.579	137.93	12.26	-14.85	15.32	17.24
J-467	125.51	0.114	137.77	12.23	-15.68	15.38	17.36
J-468	125.82	0.583	137.77	11.93	-15.98	15.08	17.05
J-469	122.89	0.466	140.54	17.62	3.95	19.16	20.13
J-470	122.59	0.570	140.54	17.91	4.23	19.45	20.42
J-475	123.86	0.486	140.47	16.57	2.52	18.16	19.15
J-476	124.12	0.451	140.47	16.31	2.29	17.90	18.89
J-477	123.04	0.604	138.23	15.16	-10.38	18.04	19.85
J-480	123.14	0.401	140.91	17.73	5.93	19.06	19.89
J-481	123.54	0.248	140.81	17.24	4.97	18.62	19.49
J-487	125.20	0.108	141.96	16.73	10.34	17.45	17.90
J-498	123.11	0.609	141.42	18.27	9.13	19.31	19.95
J-499	123.71	0.328	141.68	17.94	10.12	18.82	19.37
J-503	123.42	0.393	140.89	17.44	5.58	18.78	19.62
J-504	123.75	0.389	140.80	17.01	4.65	18.40	19.28
J-507	123.85	0.565	141.89	18.00	11.25	18.76	19.24
J-508	123.68	0.526	141.88	18.16	11.40	18.93	19.40
J-511	124.19	0.396	141.18	16.95	6.56	18.13	18.86
J-512	123.99	0.442	141.19	17.16	6.82	18.33	19.06
J-514	124.78	1.048	141.07	16.26	5.31	17.49	18.27
J-523	124.20	0.444	141.19	16.96	6.64	18.13	18.86
J-526	122.42	0.114	138.53	16.08	-7.90	18.79	20.49
J-533	126.67	0.492	137.86	11.18	-16.25	14.27	16.21
J-537	123.28	0.616	141.16	17.84	7.35	19.02	19.77
J-538	123.04	0.671	141.16	18.08	7.58	19.26	20.00
J-542	123.00	0.449	141.21	18.17	7.97	19.32	20.05
J-543	123.45	0.665	141.27	17.79	7.88	18.91	19.61
J-547	126.84	0.482	137.91	11.05	-16.12	14.12	16.04
J-548	125.35	0.119	137.91	12.54	-14.63	15.61	17.53
J-553	122.72	0.150	140.59	17.84	4.45	19.35	20.30
J-554	123.77	0.737	141.34	17.54	7.99	18.62	19.29

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-555	124.27	0.613	139.93	15.63	-1.17	17.53	18.71
J-556	124.61	1.038	140.11	15.47	-0.39	17.26	18.38
J-564	123.04	0.502	141.20	18.12	7.82	19.28	20.01
J-565	122.93	0.171	141.20	18.23	7.94	19.39	20.12
J-566	122.51	0.160	138.55	16.01	-7.88	18.70	20.39
J-568	125.22	0.478	137.81	12.57	-15.14	15.70	17.65
J-569	125.55	0.306	137.81	12.24	-15.47	15.36	17.32
J-610	125.15	0.135	137.77	12.59	-15.32	15.74	17.72
J-629	123.33	0.429	142.83	19.46	17.55	19.68	19.81
J-630	124.09	0.429	142.66	18.53	15.75	18.84	19.04
J-649	123.36	0.633	141.24	17.85	7.80	18.99	19.70
J-659	123.03	0.965	141.42	18.36	9.20	19.39	20.04
J-664	125.61	0.467	140.38	14.73	0.22	16.37	17.40
J-666	123.36	0.500	141.88	18.49	11.71	19.25	19.73
J-668	125.07	0.135	137.92	12.82	-14.34	15.88	17.80
J-671	123.57	0.381	142.83	19.22	17.31	19.44	19.57
J-679	123.00	0.137	140.88	17.84	5.89	19.19	20.03
J-681	123.70	0.715	140.66	16.93	3.87	18.40	19.33
J-682	124.03	0.137	140.78	16.72	4.27	18.12	19.00
J-683	124.76	0.716	142.30	17.51	12.91	18.03	18.35
J-684	123.88	0.542	142.38	18.46	14.27	18.94	19.23
J-694	124.34	0.527	142.83	18.45	16.55	18.67	18.80
J-705	123.50	0.527	141.88	18.34	11.57	19.11	19.59
J-706	123.93	0.293	141.88	17.91	11.14	18.68	19.16
J-748	123.57	0.433	141.88	18.27	11.50	19.04	19.52
J-753	124.68	0.322	141.97	17.26	10.92	17.97	18.42
J-754	124.98	0.788	141.79	16.78	9.55	17.60	18.11
J-761	124.57	1.336	141.26	16.65	6.69	17.78	18.48
J-762	124.16	0.161	139.06	14.87	-6.43	17.27	18.77
J-764	125.03	0.161	138.20	13.14	-12.56	16.04	17.86
J-765	127.73	0.165	137.91	10.16	-17.01	13.23	15.15
J-767	125.28	0.506	142.04	16.72	10.73	17.39	17.82
J-768	126.53	0.163	142.04	15.48	9.49	16.15	16.58
J-769	124.85	0.713	137.79	12.92	-14.87	16.06	18.02
J-770	124.20	0.611	142.24	18.00	13.05	18.56	18.91
J-771	123.94	0.814	142.00	18.02	11.87	18.72	19.15
J-772	124.54	0.166	141.34	16.77	7.21	17.85	18.53
J-788	124.17	1.372	138.52	14.33	-9.72	17.04	18.74
J-789	121.29	0.773	138.55	17.22	-6.67	19.92	21.61

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-791	125.34	0.864	141.79	16.42	9.19	17.23	17.74
J-800	124.44	0.189	141.27	16.80	6.91	17.92	18.62
J-806	125.19	0.194	137.80	12.58	-15.18	15.71	17.67
J-808	125.78	0.196	137.81	12.00	-15.72	15.13	17.09
J-809	124.02	0.822	142.06	18.01	12.17	18.67	19.08
J-811	124.46	0.958	139.01	14.53	-7.00	16.96	18.48
J-817	123.10	0.317	138.23	15.09	-10.47	17.98	19.78
J-822	123.91	0.691	137.92	13.98	-13.17	17.05	18.97
J-823	123.68	0.403	142.37	18.66	14.38	19.14	19.44
J-826	124.09	0.839	142.07	17.94	12.15	18.60	19.01
J-833	127.64	0.221	138.67	11.01	-12.30	13.63	15.28
J-836	126.10	0.214	137.79	11.67	-16.12	14.80	16.77
J-838	122.97	0.220	138.55	15.55	-8.34	18.25	19.94
J-839	126.70	1.028	137.87	11.15	-16.23	14.24	16.18
J-841	124.74	0.224	142.06	17.29	11.45	17.95	18.36
J-843	123.95	1.016	138.17	14.19	-11.64	17.11	18.93
J-844	123.13	0.318	141.03	17.87	6.73	19.12	19.91
J-846	124.86	1.138	137.87	12.99	-14.40	16.08	18.01
J-847	126.83	0.962	137.81	10.96	-16.74	14.09	16.04
J-850	123.01	0.999	139.24	16.20	-4.15	18.49	19.93
J-857	124.48	0.949	137.89	13.38	-13.92	16.46	18.39
J-858	126.12	0.333	137.81	11.66	-16.06	14.79	16.75
J-868	124.73	0.330	141.86	17.10	10.21	17.88	18.36
J-870	123.60	0.378	138.81	15.18	-7.41	17.73	19.32
J-875	126.44	0.394	137.80	11.34	-16.39	14.47	16.43
J-878	125.68	0.498	138.16	12.46	-13.44	15.38	17.21
J-882	125.36	0.551	137.87	12.49	-14.91	15.58	17.52
J-883	126.40	0.646	137.87	11.45	-15.96	14.54	16.47

Ruchi Khand DMA

In case of Richi Khand DMA, the total flow through this DMA is 3.47 MLD. This demand is applied to that DMA. As the supply for this DMA is for 5 hours, the peak factor is 4.8.



The results of calibration are presented in table below:

Pipe results for Ruchi Khand DMA

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-5	J-5	J-6	250.0	CI	70.0	1	0.004	0.000	0.000	0.000	0.000	0.000
P-6	J-7	J-6	250.0	CI	70.0	1	0.004	0.000	0.000	0.000	0.000	0.000
P-15	J-24	J-25	150.0	AC	65.0	6	6.386	0.361	4.159	25.583	1.742	0.228
P-47	J-85	J-86	150.0	AC	65.0	14	2.991	0.169	1.021	6.278	0.427	0.056
P-48	J-87	J-88	105.0	PVC	110.0	14	0.112	0.013	0.005	0.031	0.002	0.000
P-56	J-103	J-104	105.0	PVC	110.0	15	0.122	0.014	0.006	0.036	0.003	0.000
P-62	J-112	J-113	250.0	CI	70.0	16	8.852	0.180	0.551	3.391	0.231	0.030
P-68	J-124	J-125	46.6	PVC	110.0	17	2.477	1.452	80.764	496.723	33.821	4.421
P-93	J-169	J-170	250.0	CI	70.0	20	2.374	0.048	0.048	0.296	0.020	0.003
P-104	J-190	J-191	105.0	PVC	110.0	21	0.980	0.113	0.277	1.707	0.116	0.015
P-107	J-196	J-197	105.0	PVC	110.0	21	0.892	0.103	0.233	1.432	0.098	0.013
P-117	J-210	J-196	105.0	PVC	110.0	22	0.182	0.021	0.012	0.076	0.005	0.001
P-118	J-211	J-212	105.0	PVC	110.0	22	2.793	0.323	1.929	11.865	0.808	0.106
P-120	J-213	J-214	105.0	PVC	110.0	22	1.274	0.147	0.450	2.772	0.188	0.025
P-121	J-215	J-216	105.0	PVC	110.0	22	0.503	0.058	0.080	0.495	0.034	0.004
P-122	J-217	J-218	152.6	PVC	110.0	22	0.183	0.010	0.002	0.012	0.001	0.000
P-125	J-223	J-224	105.0	PVC	110.0	22	4.501	0.520	4.668	28.710	1.955	0.255

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-127	J-214	J-227	105.0	PVC	110.0	23	0.613	0.071	0.116	0.715	0.049	0.007
P-128	J-228	J-229	152.6	PVC	110.0	23	16.108	0.881	8.012	49.276	3.355	0.438
P-130	J-232	J-233	46.6	PVC	110.0	23	1.515	0.889	32.508	199.934	13.613	1.780
P-136	J-240	J-241	46.6	PVC	110.0	23	0.773	0.453	9.351	57.512	3.916	0.512
P-144	J-251	J-252	105.0	PVC	110.0	24	3.604	0.416	3.092	19.017	1.295	0.169
P-149	J-260	J-261	105.0	PVC	110.0	25	3.187	0.368	2.464	15.151	1.032	0.135
P-152	J-265	J-266	46.6	PVC	110.0	25	1.592	0.933	35.604	218.972	14.910	1.949
P-153	J-267	J-191	105.0	PVC	110.0	25	1.883	0.217	0.930	5.716	0.389	0.051
P-157	J-272	J-273	105.0	PVC	110.0	25	2.759	0.319	1.885	11.594	0.790	0.103
P-165	J-283	J-284	152.6	PVC	110.0	26	3.003	0.164	0.357	2.196	0.149	0.020
P-167	J-287	J-288	46.6	PVC	110.0	26	1.552	0.910	33.973	208.944	14.227	1.860
P-170	J-292	J-287	46.6	PVC	110.0	26	2.332	1.367	72.223	444.193	30.244	3.954
P-172	J-295	J-296	105.0	PVC	110.0	26	1.191	0.138	0.398	2.446	0.166	0.022
P-173	J-297	J-232	46.6	PVC	110.0	26	1.594	0.935	35.709	219.619	14.954	1.955

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-180	J-305	J-306	190.8	PVC	110.0	27	38.681	1.353	13.669	84.066	5.724	0.748
P-182	J-308	J-309	152.6	PVC	110.0	27	17.191	0.940	9.037	55.583	3.784	0.495
P-185	J-265	J-313	100.0	AC	65.0	27	2.537	0.323	5.423	33.354	2.271	0.297
P-188	J-216	J-190	105.0	PVC	110.0	27	0.405	0.047	0.054	0.331	0.023	0.003
P-191	J-319	J-320	105.0	PVC	110.0	27	3.223	0.372	2.514	15.461	1.053	0.137
P-192	J-321	J-211	105.0	PVC	110.0	27	0.784	0.091	0.184	1.129	0.077	0.010
P-193	J-214	J-321	105.0	PVC	110.0	27	2.478	0.286	1.545	9.504	0.647	0.084
P-194	J-6	J-169	250.0	CI	70.0	29	1.086	0.022	0.011	0.070	0.005	0.001
P-203	J-309	J-332	152.6	PVC	110.0	28	15.703	0.859	7.643	47.006	3.201	0.418
P-204	J-333	J-260	105.0	PVC	110.0	28	3.298	0.381	2.625	16.142	1.099	0.144
P-206	J-273	J-321	105.0	PVC	110.0	28	2.370	0.274	1.424	8.755	0.596	0.078
P-213	J-341	J-267	150.0	AC	65.0	28	4.959	0.281	2.604	16.017	1.091	0.143
P-214	J-233	J-308	46.6	PVC	110.0	28	1.359	0.797	26.559	163.347	11.122	1.454
P-218	J-347	J-348	105.0	PVC	110.0	29	0.527	0.061	0.088	0.541	0.037	0.005

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-222	J-353	J-319	105.0	PVC	110.0	29	4.618	0.533	4.894	30.099	2.049	0.268
P-226	J-357	J-358	150.0	AC	65.0	29	6.847	0.387	4.733	29.109	1.982	0.259
P-237	J-241	J-370	105.0	PVC	110.0	30	5.088	0.588	5.856	36.017	2.452	0.321
P-242	J-216	J-378	105.0	PVC	110.0	31	0.252	0.029	0.022	0.137	0.009	0.002
P-243	J-103	J-272	105.0	PVC	110.0	30	2.205	0.255	1.245	7.655	0.521	0.068
P-246	J-223	J-296	152.6	PVC	110.0	31	3.042	0.166	0.365	2.248	0.153	0.020
P-251	J-386	J-387	46.6	PVC	110.0	31	0.134	0.079	0.365	2.244	0.153	0.020
P-252	J-388	J-389	105.0	PVC	110.0	31	1.008	0.116	0.292	1.797	0.123	0.016
P-254	J-392	J-297	46.6	PVC	110.0	31	3.467	2.033	150.570	926.049	63.054	8.243
P-255	J-393	J-218	46.6	PVC	110.0	31	1.242	0.728	22.496	138.354	9.420	1.231
P-260	J-399	J-400	46.6	PVC	110.0	31	0.944	0.553	13.531	83.217	5.666	0.741
P-261	J-401	J-283	105.0	PVC	110.0	31	3.784	0.437	3.384	20.815	1.417	0.185
P-273	J-413	J-414	105.0	PVC	110.0	32	1.562	0.180	0.658	4.044	0.275	0.036
P-274	J-347	J-415	105.0	PVC	110.0	32	1.907	0.220	0.951	5.850	0.398	0.052

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-276	J-370	J-417	105.0	PVC	110.0	32	26.125	3.017	121.215	745.504	50.761	6.636
P-278	J-418	J-332	152.6	PVC	110.0	32	8.531	0.466	2.469	15.183	1.034	0.135
P-279	J-191	J-197	105.0	PVC	110.0	32	0.258	0.030	0.023	0.144	0.010	0.001
P-281	J-190	J-196	105.0	PVC	110.0	33	0.085	0.010	0.003	0.019	0.001	0.000
P-302	J-251	J-442	105.0	PVC	110.0	34	5.662	0.654	7.139	43.904	2.989	0.391
P-304	J-443	J-444	150.0	AC	65.0	35	13.720	0.776	17.146	105.455	7.180	0.939
P-305	J-197	J-86	105.0	PVC	110.0	35	1.360	0.157	0.508	3.127	0.213	0.028
P-313	J-452	J-453	105.0	PVC	110.0	35	5.866	0.677	7.623	46.883	3.192	0.418
P-315	J-223	J-241	105.0	PVC	110.0	35	3.589	0.414	3.068	18.871	1.285	0.168
P-320	J-460	J-452	105.0	PVC	110.0	35	1.870	0.216	0.918	5.643	0.384	0.050
P-326	J-465	J-466	150.0	AC	65.0	36	0.293	0.017	0.014	0.085	0.006	0.001
P-329	J-471	J-472	105.0	PVC	110.0	36	0.075	0.009	0.003	0.015	0.001	0.000
P-334	J-478	J-479	105.0	PVC	110.0	36	0.787	0.091	0.185	1.135	0.077	0.010
P-336	J-482	J-124	46.6	PVC	110.0	36	0.295	0.173	1.574	9.682	0.659	0.086

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-337	J-261	J-273	105.0	PVC	110.0	51	0.467	0.054	0.070	0.432	0.029	0.004
P-347	J-491	J-492	150.0	AC	65.0	37	8.441	0.478	6.973	42.887	2.920	0.382
P-364	J-515	J-392	46.6	PVC	110.0	38	1.241	0.728	22.471	138.203	9.410	1.230
P-365	J-170	J-516	250.0	CI	70.0	38	6.398	0.130	0.302	1.859	0.127	0.016
P-366	J-227	J-517	105.0	PVC	110.0	38	0.310	0.036	0.033	0.203	0.014	0.002
P-369	J-284	J-522	152.6	PVC	110.0	38	10.044	0.549	3.341	20.546	1.399	0.183
P-377	J-224	J-240	152.6	PVC	110.0	39	1.497	0.082	0.098	0.605	0.041	0.006
P-384	J-218	J-224	152.6	PVC	110.0	39	2.182	0.119	0.198	1.216	0.083	0.011
P-405	J-549	J-550	100.0	AC	65.0	40	0.275	0.035	0.088	0.544	0.037	0.005
P-420	J-567	J-213	105.0	PVC	110.0	41	1.211	0.140	0.410	2.525	0.172	0.022
P-423	RUCHI KHAND 20 LL	J-570	250.0	CI	70.0	41	207.778	4.233	190.433	1171.212	79.746	10.425
P-430	J-85	J-567	105.0	PVC	110.0	42	0.425	0.049	0.059	0.363	0.025	0.003
P-484	J-125	J-292	46.6	PVC	110.0	44	8.384	4.916	772.517	4751.187	323.503	42.291

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-497	J-646	J-113	46.6	PVC	110.0	44	1.713	1.004	40.774	250.772	17.075	2.232
P-510	J-341	J-85	150.0	AC	65.0	51	3.434	0.194	1.318	8.107	0.552	0.072
P-530	J-492	J-353	105.0	PVC	110.0	46	9.170	1.059	17.437	107.242	7.302	0.955
P-540	J-443	J-678	105.0	PVC	110.0	46	9.099	1.051	17.187	105.703	7.197	0.941
P-565	J-695	J-696	250.0	CI	70.0	47	59.050	1.203	18.529	113.956	7.759	1.014
P-573	J-267	J-215	150.0	AC	65.0	48	2.241	0.127	0.598	3.680	0.251	0.033
P-577	J-703	J-704	250.0	CI	70.0	48	31.867	0.649	5.912	36.360	2.476	0.324
P-585	J-516	J-708	250.0	CI	70.0	49	0.399	0.008	0.002	0.011	0.001	0.000
P-586	J-709	J-491	150.0	AC	65.0	49	7.548	0.427	5.670	34.871	2.374	0.310
P-588	J-320	J-272	105.0	PVC	110.0	49	1.408	0.163	0.543	3.337	0.227	0.030
P-591	J-703	J-418	152.6	PVC	110.0	49	55.044	3.010	77.997	479.705	32.663	4.270
P-596	J-417	J-712	105.0	PVC	110.0	49	29.221	3.375	149.148	917.300	62.458	8.165
P-608	J-252	J-719	105.0	PVC	110.0	49	0.406	0.047	0.054	0.333	0.023	0.003
P-633	J-6	J-735	250.0	CI	70.0	51	0.417	0.008	0.002	0.012	0.001	0.000

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-637	J-515	J-232	46.6	PVC	110.0	81	2.040	1.196	56.394	346.840	23.616	3.087
P-641	J-261	J-211	105.0	PVC	110.0	51	1.677	0.194	0.750	4.614	0.314	0.041
P-647	J-740	J-741	46.6	PVC	110.0	52	0.425	0.249	3.080	18.941	1.290	0.169
P-655	J-297	J-309	46.6	PVC	110.0	52	0.612	0.359	6.061	37.275	2.538	0.332
P-659	J-696	J-747	250.0	CI	70.0	67	75.711	1.542	29.359	180.567	12.295	1.607
P-663	J-320	J-260	105.0	PVC	110.0	53	0.757	0.087	0.172	1.058	0.072	0.009
P-667	J-751	J-24	150.0	AC	65.0	53	0.436	0.025	0.029	0.178	0.012	0.002
P-669	J-287	J-265	100.0	AC	65.0	53	0.083	0.011	0.010	0.060	0.004	0.001
P-672	J-319	J-333	105.0	PVC	110.0	53	0.494	0.057	0.078	0.480	0.033	0.004
P-677	J-288	J-266	100.0	AC	65.0	54	0.431	0.055	0.204	1.254	0.085	0.011
P-686	J-212	J-227	105.0	PVC	110.0	54	0.638	0.074	0.125	0.771	0.053	0.007
P-688	J-169	J-763	152.6	PVC	110.0	54	0.445	0.024	0.010	0.064	0.004	0.001
P-691	J-703	J-709	150.0	AC	65.0	54	14.497	0.820	18.987	116.779	7.951	1.040
P-697	J-112	J-25	150.0	AC	65.0	55	7.305	0.413	5.336	32.818	2.234	0.292

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-702	J-387	J-400	46.6	PVC	110.0	55	0.922	0.541	12.962	79.719	5.428	0.710
P-714	J-399	J-386	46.6	PVC	110.0	56	0.580	0.340	5.484	33.730	2.297	0.300
P-717	J-777	J-393	46.6	PVC	110.0	60	0.494	0.290	4.076	25.069	1.707	0.223
P-718	J-778	J-358	150.0	AC	65.0	56	6.788	0.384	4.658	28.648	1.951	0.255
P-729	J-444	J-695	150.0	AC	65.0	57	25.581	1.448	54.357	334.311	22.763	2.976
P-737	J-783	J-295	105.0	PVC	110.0	57	0.862	0.100	0.219	1.345	0.092	0.012
P-740	J-401	J-88	105.0	PVC	110.0	58	1.447	0.167	0.570	3.509	0.239	0.031
P-741	J-704	J-491	152.6	PVC	110.0	58	24.981	1.366	18.057	111.055	7.562	0.989
P-750	J-785	J-112	200.0	CI	70.0	59	0.481	0.015	0.007	0.046	0.003	0.000
P-755	J-332	J-297	152.6	PVC	110.0	81	6.015	0.329	1.292	7.948	0.541	0.071
P-758	J-787	J-313	100.0	AC	65.0	60	0.489	0.062	0.257	1.582	0.108	0.014
P-785	J-24	J-413	105.0	PVC	110.0	63	4.949	0.572	5.565	34.224	2.330	0.305
P-789	J-795	J-703	250.0	CI	70.0	63	70.655	1.439	25.832	158.874	10.817	1.414
P-803	J-357	J-801	105.0	PVC	110.0	64	4.978	0.575	5.625	34.593	2.355	0.308

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-811	J-414	J-801	105.0	PVC	110.0	65	1.427	0.165	0.556	3.421	0.233	0.031
P-824	J-348	J-388	105.0	PVC	110.0	66	0.925	0.107	0.249	1.532	0.104	0.014
P-862	J-252	J-460	105.0	PVC	110.0	69	2.034	0.235	1.072	6.593	0.449	0.059
P-871	J-215	J-830	150.0	AC	65.0	71	0.580	0.033	0.049	0.301	0.021	0.003
P-872	J-88	J-783	105.0	PVC	110.0	69	0.179	0.021	0.012	0.073	0.005	0.001
P-875	J-471	J-212	105.0	PVC	110.0	70	0.957	0.110	0.265	1.631	0.111	0.014
P-877	J-415	J-831	105.0	PVC	110.0	70	0.573	0.066	0.103	0.632	0.043	0.006
P-886	J-233	J-240	46.6	PVC	110.0	72	1.170	0.686	20.126	123.781	8.428	1.102
P-889	J-460	J-471	105.0	PVC	110.0	72	2.457	0.284	1.521	9.357	0.637	0.083
P-891	J-472	J-452	105.0	PVC	110.0	72	2.821	0.326	1.965	12.087	0.823	0.108
P-893	J-333	J-678	105.0	PVC	110.0	73	4.067	0.470	3.869	23.795	1.620	0.212
P-898	J-211	J-251	105.0	PVC	110.0	73	3.330	0.385	2.671	16.429	1.119	0.146
P-916	J-86	J-840	150.0	AC	65.0	75	0.618	0.035	0.055	0.338	0.023	0.003
P-917	J-353	J-103	105.0	PVC	110.0	75	3.317	0.383	2.651	16.307	1.110	0.145

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-921	J-842	J-479	105.0	PVC	110.0	76	0.624	0.072	0.120	0.740	0.050	0.007
P-925	J-295	J-401	105.0	PVC	110.0	76	0.982	0.113	0.278	1.712	0.117	0.015
P-927	J-479	J-472	105.0	PVC	110.0	76	1.382	0.160	0.524	3.225	0.220	0.029
P-935	J-478	J-471	105.0	PVC	110.0	77	1.251	0.144	0.436	2.679	0.182	0.024
P-939	J-646	J-741	46.6	PVC	110.0	77	1.966	1.152	52.625	323.660	22.038	2.881
P-953	J-801	J-348	105.0	PVC	110.0	80	1.834	0.212	0.885	5.443	0.371	0.048
P-954	J-414	J-388	105.0	PVC	110.0	80	1.535	0.177	0.636	3.914	0.267	0.035
P-955	J-358	J-848	150.0	AC	65.0	80	6.713	0.380	4.563	28.061	1.911	0.250
P-957	J-550	J-399	46.6	PVC	110.0	80	1.010	0.592	15.330	94.286	6.420	0.839
P-973	J-848	J-709	150.0	AC	65.0	83	9.621	0.544	8.886	54.653	3.721	0.486
P-984	J-292	J-313	100.0	AC	65.0	106	4.607	0.587	16.372	100.690	6.856	0.896
P-991	J-853	J-223	105.0	PVC	110.0	86	0.702	0.081	0.150	0.920	0.063	0.008
P-993	J-854	J-392	46.6	PVC	110.0	101	0.831	0.487	10.685	65.713	4.474	0.585
P-998	J-570	J-747	250.0	CI	70.0	88	99.095	2.019	48.332	297.257	20.240	2.646

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-999	J-288	J-400	46.6	PVC	110.0	88	0.259	0.152	1.230	7.562	0.515	0.067
P-1001	J-856	J-305	190.8	PVC	110.0	104	42.027	1.470	15.938	98.025	6.674	0.873
P-1002	J-266	J-387	46.6	PVC	110.0	89	0.649	0.380	6.754	41.537	2.828	0.370
P-1004	J-856	J-795	190.8	PVC	110.0	89	47.889	1.675	20.299	124.845	8.501	1.111
P-1010	J-778	J-795	250.0	CI	70.0	91	20.776	0.423	2.677	16.465	1.121	0.147
P-1014	J-213	J-478	105.0	PVC	110.0	92	1.212	0.140	0.411	2.529	0.172	0.023
P-1018	J-25	J-357	150.0	AC	65.0	92	0.342	0.019	0.018	0.113	0.008	0.001
P-1020	J-308	J-370	152.6	PVC	110.0	93	19.764	1.081	11.702	71.968	4.900	0.641
P-1023	J-747	J-522	250.0	CI	70.0	93	21.346	0.435	2.815	17.311	1.179	0.154
P-1025	J-389	J-415	105.0	PVC	110.0	94	0.278	0.032	0.027	0.165	0.011	0.001
P-1031	J-848	J-861	150.0	AC	65.0	96	0.787	0.045	0.086	0.530	0.036	0.005
P-1038	J-712	J-704	250.0	CI	70.0	97	58.513	1.192	18.218	112.044	7.629	0.997
P-1053	J-864	J-515	105.0	PVC	110.0	140	1.153	0.133	0.375	2.306	0.157	0.021
P-1057	J-251	J-678	105.0	PVC	110.0	104	3.205	0.370	2.488	15.302	1.042	0.136

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1058	J-417	J-570	400.0	CI	70.0	104	106.431	0.847	5.590	34.380	2.341	0.306
P-1060	J-113	J-778	250.0	CI	70.0	105	11.922	0.243	0.957	5.886	0.401	0.052
P-1067	J-867	J-229	105.0	PVC	110.0	108	0.884	0.102	0.229	1.410	0.096	0.013
P-1073	J-284	J-296	152.6	PVC	110.0	111	5.608	0.307	1.135	6.983	0.475	0.062
P-1078	J-341	J-709	150.0	AC	65.0	113	9.971	0.564	9.494	58.393	3.976	0.520
P-1079	J-869	J-306	105.0	PVC	110.0	115	23.731	2.741	101.453	623.962	42.485	5.554
P-1083	J-413	J-389	105.0	PVC	110.0	141	1.453	0.168	0.575	3.536	0.241	0.031
P-1092	J-400	J-549	105.0	PVC	110.0	153	4.817	0.556	5.292	32.550	2.216	0.290
P-1099	J-453	J-872	46.6	PVC	110.0	201	1.647	0.965	37.914	233.183	15.877	2.076
P-1102	J-873	J-228	152.6	PVC	110.0	125	9.755	0.533	3.165	19.464	1.325	0.173
P-1106	J-549	J-873	105.0	PVC	110.0	125	7.705	0.890	12.631	77.684	5.289	0.691
P-1113	J-453	J-442	105.0	PVC	110.0	128	1.650	0.191	0.728	4.476	0.305	0.040
P-1117	J-712	J-695	250.0	CI	70.0	129	31.550	0.643	5.804	35.693	2.430	0.318
P-1120	J-741	J-305	46.6	PVC	110.0	131	1.194	0.700	20.893	128.496	8.749	1.144

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1128	J-453	J-465	150.0	AC	65.0	175	10.287	0.582	10.059	61.868	4.212	0.551
P-1136	J-170	J-283	152.6	PVC	110.0	140	2.400	0.131	0.236	1.450	0.099	0.013
P-1141	J-124	J-741	46.6	PVC	110.0	143	0.573	0.336	5.368	33.016	2.248	0.294
P-1143	J-347	J-358	105.0	PVC	110.0	144	4.116	0.475	3.955	24.323	1.656	0.216
P-1145	J-418	J-417	200.0	CI	70.0	145	48.373	1.540	37.974	233.550	15.902	2.079
P-1147	J-306	J-125	190.8	PVC	110.0	148	12.570	0.440	1.705	10.485	0.714	0.093
P-1149	J-491	J-567	105.0	PVC	110.0	150	6.590	0.761	9.456	58.159	3.960	0.518
P-1151	J-442	J-444	150.0	AC	65.0	150	9.877	0.559	9.328	57.370	3.906	0.511
P-1153	J-228	J-550	100.0	AC	65.0	208	3.433	0.437	9.499	58.421	3.978	0.520
P-1157	J-492	J-443	150.0	AC	65.0	155	2.682	0.152	0.834	5.130	0.349	0.046
P-1163	J-516	J-522	250.0	CI	70.0	166	8.865	0.181	0.553	3.400	0.232	0.030
P-1175	J-881	J-567	105.0	PVC	110.0	185	1.523	0.176	0.627	3.859	0.263	0.034
P-1176	J-856	J-646	105.0	PVC	110.0	184	2.763	0.319	1.890	11.625	0.792	0.103
P-1182	J-465	J-696	150.0	AC	65.0	207	14.016	0.793	17.838	109.709	7.470	0.977

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1192	J-229	J-869	105.0	PVC	110.0	287	20.424	2.359	76.830	472.522	32.173	4.206

Node/ Junction results for Ruchi Khand DMA

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-5	124.36	0.004	138.63	14.24	-49.88	21.47	26.00
J-6	124.37	0.662	138.63	14.22	-49.89	21.46	25.99
J-7	124.39	0.004	138.63	14.21	-49.91	21.45	25.98
J-24	123.46	1.001	131.04	7.56	-95.55	19.20	26.49
J-25	123.46	1.261	131.06	7.58	-95.40	19.21	26.49
J-85	123.69	0.868	131.16	7.45	-95.03	19.02	26.26
J-86	124.29	1.014	131.15	6.85	-95.70	18.42	25.67
J-87	124.41	0.112	138.45	14.02	-50.98	21.35	25.94
J-88	124.25	1.156	138.45	14.18	-50.82	21.51	26.11
J-103	123.00	0.990	131.32	8.31	-93.33	19.78	26.96
J-104	123.03	0.122	131.32	8.28	-93.36	19.75	26.94
J-112	122.67	1.066	131.36	8.67	-92.81	20.12	27.29
J-113	122.99	1.358	131.37	8.36	-93.07	19.81	26.98
J-124	122.63	1.608	126.27	3.64	-123.96	18.04	27.06
J-125	122.15	1.709	127.63	5.46	-115.19	19.08	27.61
J-169	124.72	0.843	138.63	13.88	-50.24	21.11	25.64
J-170	124.96	1.623	138.63	13.64	-50.47	20.88	25.41
J-190	122.96	0.661	131.13	8.15	-94.52	19.73	26.99
J-191	122.93	0.644	131.13	8.19	-94.45	19.77	27.02
J-196	124.50	0.624	131.13	6.62	-96.05	18.20	25.46
J-197	124.47	0.726	131.13	6.65	-95.99	18.24	25.49
J-210	125.57	0.182	131.13	5.55	-97.12	17.13	24.39
J-211	123.02	1.430	131.20	8.17	-94.09	19.71	26.93
J-212	123.07	1.198	131.16	8.07	-94.41	19.64	26.88
J-213	123.36	1.273	131.15	7.77	-94.79	19.34	26.59
J-214	123.23	0.591	131.16	7.91	-94.59	19.48	26.72
J-215	122.78	1.158	131.13	8.33	-94.34	19.92	27.17
J-216	122.99	0.656	131.12	8.12	-94.56	19.70	26.96
J-217	126.19	0.183	138.35	12.13	-53.38	19.53	24.16
J-218	126.65	0.757	138.35	11.68	-53.84	19.07	23.70
J-223	127.68	1.427	138.47	10.77	-54.17	18.10	22.69
J-224	127.41	0.822	138.36	10.93	-54.55	18.32	22.95
J-227	123.63	0.941	131.15	7.51	-95.01	19.08	26.32
J-228	122.66	2.920	93.91	-28.70	-322.67	4.48	25.26
J-229	122.56	3.431	94.09	-28.41	-321.45	4.66	25.37
J-232	126.81	1.069	136.16	9.34	-67.42	18.00	23.43
J-233	125.98	1.013	136.91	10.90	-62.05	19.14	24.29
J-240	126.88	1.100	138.36	11.45	-54.04	18.84	23.47

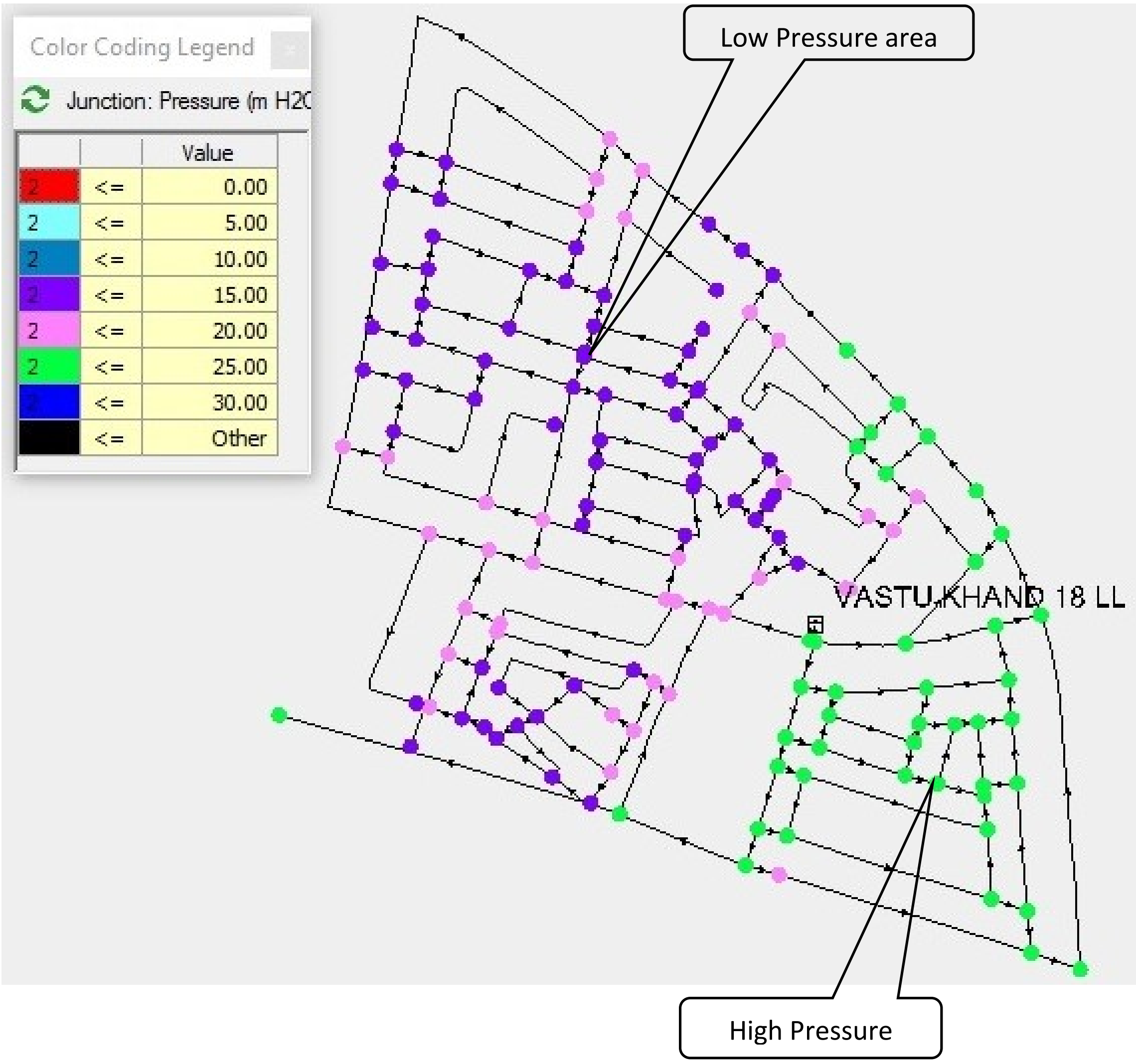
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-241	127.23	0.726	138.57	11.32	-53.06	18.59	23.14
J-251	123.15	1.933	131.40	8.23	-93.02	19.66	26.81
J-252	123.67	1.164	131.33	7.65	-93.99	19.12	26.30
J-260	123.00	0.868	131.30	8.29	-93.46	19.77	26.96
J-261	123.00	1.043	131.24	8.23	-93.84	19.74	26.96
J-265	123.70	0.862	91.89	-31.74	-336.05	2.60	24.11
J-266	124.03	1.374	91.00	-32.96	-341.86	1.90	23.73
J-267	122.06	0.835	131.15	9.07	-93.44	20.64	27.89
J-272	123.00	0.854	131.29	8.27	-93.57	19.76	26.96
J-273	123.00	0.855	131.24	8.22	-93.86	19.74	26.96
J-283	125.03	1.620	138.59	13.54	-50.74	20.79	25.34
J-284	125.38	1.433	138.60	13.20	-51.03	20.45	24.99
J-287	122.80	0.863	91.89	-30.85	-335.16	3.50	25.00
J-288	123.72	1.379	91.01	-32.65	-341.48	2.21	24.04
J-292	122.08	1.446	93.78	-28.25	-322.88	5.00	25.83
J-295	126.57	1.311	138.47	11.87	-53.07	19.20	23.79
J-296	127.26	1.376	138.48	11.19	-53.69	18.51	23.10
J-297	126.88	1.565	137.11	10.21	-61.72	18.32	23.41
J-305	125.35	2.152	128.24	2.89	-114.60	16.15	24.45
J-306	125.21	2.379	127.88	2.66	-116.70	16.13	24.57
J-308	124.95	1.215	137.66	12.69	-56.38	20.48	25.36
J-309	124.99	0.875	137.42	12.41	-57.89	20.34	25.31
J-313	124.53	1.581	92.04	-32.42	-335.99	1.84	23.29
J-319	123.00	0.901	131.38	8.36	-92.99	19.80	26.97
J-320	123.00	1.057	131.31	8.30	-93.40	19.77	26.96
J-321	123.09	0.677	131.20	8.09	-94.19	19.64	26.87
J-332	125.03	1.158	137.21	12.16	-59.23	20.22	25.26
J-333	122.99	1.263	131.38	8.37	-93.01	19.81	26.97
J-341	122.25	1.579	131.23	8.96	-93.17	20.49	27.71
J-347	122.26	1.682	130.64	8.36	-96.82	20.23	27.66
J-348	122.15	1.436	130.63	8.46	-96.73	20.34	27.77
J-353	123.00	1.236	131.52	8.51	-92.11	19.86	26.97
J-357	122.57	1.528	131.06	8.48	-94.50	20.10	27.38
J-358	121.55	2.538	131.20	9.63	-92.63	21.17	28.40
J-370	126.41	1.274	138.75	12.32	-51.16	19.48	23.97
J-378	124.39	0.252	131.12	6.72	-95.96	18.30	25.56
J-386	123.77	0.714	90.39	-33.31	-345.34	1.90	23.96
J-387	124.12	1.437	90.40	-33.65	-345.62	1.56	23.61
J-388	123.61	1.452	130.62	6.99	-98.28	18.88	26.32

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-389	122.44	2.183	130.61	8.15	-97.18	20.03	27.48
J-392	126.67	1.395	132.44	5.76	-90.13	16.59	23.36
J-393	126.14	0.748	137.66	11.50	-57.60	19.29	24.18
J-399	122.91	1.374	90.70	-32.15	-342.60	2.89	24.83
J-400	123.71	2.692	91.12	-32.52	-340.80	2.27	24.06
J-401	125.06	1.355	138.49	13.40	-51.43	20.71	25.30
J-413	124.97	1.934	130.69	5.71	-99.20	17.55	24.96
J-414	124.19	1.454	130.67	6.47	-98.55	18.32	25.74
J-415	122.39	1.611	130.61	8.20	-97.14	20.09	27.53
J-417	125.49	2.712	142.66	17.14	-26.27	22.03	25.10
J-418	123.84	1.860	137.13	13.26	-58.54	21.37	26.44
J-442	123.11	2.565	131.65	8.52	-91.47	19.81	26.87
J-443	122.41	1.940	132.45	10.02	-85.82	20.84	27.62
J-444	122.21	1.985	133.05	10.82	-81.97	21.29	27.85
J-452	122.42	1.175	131.29	8.85	-93.00	20.34	27.54
J-453	121.95	4.425	131.55	9.59	-90.88	20.92	28.03
J-460	124.04	1.447	131.25	7.19	-94.82	18.71	25.92
J-465	123.02	3.436	133.32	10.27	-81.12	20.59	27.05
J-466	123.30	0.293	133.32	10.00	-81.40	20.32	26.78
J-471	122.72	2.088	131.14	8.40	-94.17	19.98	27.23
J-472	121.75	1.514	131.14	9.37	-93.21	20.95	28.20
J-478	124.76	1.676	131.11	6.34	-96.41	17.93	25.19
J-479	124.15	1.545	131.10	6.94	-95.84	18.54	25.80
J-482	122.51	0.295	126.22	3.70	-124.18	18.14	27.18
J-491	122.23	2.402	132.58	10.33	-84.87	21.07	27.80
J-492	123.00	1.952	132.32	9.30	-87.21	20.20	27.02
J-515	126.45	2.128	131.60	5.14	-95.12	16.45	23.53
J-516	125.42	2.069	138.64	13.19	-50.86	20.42	24.95
J-517	124.25	0.310	131.15	6.88	-95.64	18.45	25.70
J-522	125.10	2.436	138.73	13.61	-49.98	20.78	25.28
J-549	123.08	2.613	91.93	-31.09	-335.21	3.23	24.73
J-550	123.29	2.698	91.93	-31.30	-335.44	3.02	24.52
J-567	123.58	3.431	131.16	7.57	-94.89	19.14	26.38
J-570	125.09	2.252	143.24	18.11	-22.31	22.67	25.53
J-646	122.30	2.510	129.56	7.24	-103.48	19.74	27.57
J-678	122.86	1.827	131.66	8.78	-91.15	20.05	27.12
J-695	123.12	1.918	136.14	12.99	-63.93	21.67	27.11
J-696	122.72	2.644	137.01	14.26	-58.14	22.43	27.55
J-703	121.87	1.759	133.34	11.44	-79.86	21.75	28.20

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-704	122.78	1.665	133.62	10.82	-79.02	20.96	27.31
J-708	123.81	0.399	138.64	14.80	-49.26	22.02	26.55
J-709	120.67	2.453	132.30	11.61	-85.01	22.51	29.34
J-712	123.93	2.258	135.38	11.43	-69.35	20.54	26.25
J-719	123.27	0.406	131.32	8.04	-93.61	19.51	26.69
J-735	122.96	0.417	138.63	15.63	-48.49	22.87	27.40
J-740	120.40	0.425	125.35	4.94	-127.43	19.88	29.23
J-741	122.22	3.308	125.51	3.28	-128.26	18.13	27.43
J-747	123.34	2.039	138.99	15.62	-46.62	22.64	27.04
J-751	124.09	0.436	131.04	6.93	-96.19	18.57	25.86
J-763	124.69	0.445	138.63	13.90	-50.22	21.14	25.67
J-777	125.72	0.494	137.41	11.67	-58.69	19.61	24.58
J-778	122.34	2.065	131.47	9.11	-91.81	20.50	27.63
J-783	125.29	1.041	138.45	13.14	-51.86	20.48	25.07
J-785	123.73	0.481	131.36	7.61	-93.87	19.06	26.23
J-787	124.59	0.489	92.02	-32.50	-336.14	1.77	23.23
J-795	121.53	1.990	131.71	10.16	-89.51	21.41	28.45
J-801	122.32	1.717	130.70	8.36	-96.47	20.19	27.60
J-830	123.58	0.580	131.12	7.53	-95.15	19.12	26.37
J-831	124.57	0.573	130.60	6.02	-99.36	17.91	25.36
J-840	126.19	0.618	131.14	4.95	-97.62	16.52	23.77
J-842	122.38	0.624	131.09	8.70	-94.13	20.30	27.57
J-848	120.37	2.121	131.57	11.18	-89.21	22.51	29.60
J-853	125.84	0.702	138.45	12.59	-52.42	19.92	24.52
J-854	126.12	0.831	131.36	5.23	-96.23	16.68	23.85
J-856	124.61	3.100	129.91	5.28	-103.65	17.57	25.27
J-861	123.28	0.787	131.56	8.26	-92.17	19.60	26.70
J-864	126.14	1.153	131.54	5.39	-95.13	16.74	23.84
J-867	122.70	0.884	94.06	-28.58	-321.74	4.51	25.23
J-869	125.53	3.308	116.16	-9.35	-188.91	10.92	23.61
J-872	121.03	1.647	123.95	2.91	-136.63	18.66	28.53
J-873	122.51	2.050	93.51	-28.94	-324.94	4.47	25.39
J-881	123.62	1.523	131.05	7.42	-95.65	19.05	26.33

Vastu Khand DMA

In case of Vastu Khand DMA, the total flow through this DMA is 2.06 MLD. This demand is applied to that DMA. As the supply for this DMA is for 5 hours, the peak factor is 4.8.



The results of calibration are presented in table below:

Pipe results for Vastu Khand DMA

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-8	J-10	J-11	105.0	PVC	110.0	3	7.884	0.910	13.180	81.038	5.515	0.719
P-9	J-12	J-13	250.0	CI	70.0	5	65.642	1.337	22.542	138.599	9.436	1.233
P-10	J-14	J-15	100.0	CI	70.0	5	4.146	0.528	11.739	72.188	4.916	0.642
P-18	J-29	J-30	105.0	PVC	110.0	6	1.477	0.171	0.593	3.644	0.248	0.033
P-25	J-43	J-44	105.0	PVC	110.0	8	1.790	0.207	0.846	5.203	0.354	0.046
P-32	J-56	J-57	150.0	AC	65.0	10	23.526	1.331	46.547	286.211	19.485	2.547
P-33	J-58	J-59	100.0	CI	70.0	10	1.023	0.130	0.877	5.415	0.368	0.048
P-34	J-60	J-61	150.0	AC	65.0	12	1.234	0.070	0.198	1.218	0.083	0.011
P-53	J-97	J-98	150.0	AC	65.0	15	36.880	2.087	107.024	658.073	44.801	5.857
P-57	VASTU KHAND 18 LL	J-12	250.0	CI	70.0	15	114.468	2.332	63.129	388.169	26.426	3.455
P-60	J-109	J-110	105.0	PVC	110.0	15	1.359	0.157	0.508	3.124	0.213	0.028
P-61	J-61	J-111	150.0	AC	65.0	15	1.110	0.063	0.163	1.001	0.068	0.008
P-75	J-137	J-138	100.0	CI	70.0	18	1.265	0.161	1.303	8.023	0.546	0.071
P-76	J-139	J-60	150.0	AC	65.0	18	1.369	0.077	0.240	1.478	0.101	0.013
P-77	J-140	J-141	100.0	AC	65.0	18	5.300	0.675	21.225	130.509	8.885	1.161
P-79	J-144	J-145	105.0	PVC	110.0	18	11.795	1.362	27.792	170.892	11.634	1.521
P-80	J-146	J-147	46.6	PVC	110.0	18	0.083	0.048	0.149	0.915	0.062	0.008
P-98	J-179	J-180	105.0	PVC	110.0	20	2.061	0.238	1.099	6.756	0.460	0.060
P-100	J-183	J-184	46.6	PVC	110.0	20	0.093	0.055	0.185	1.139	0.078	0.010
P-106	J-194	J-195	100.0	CI	70.0	21	0.908	0.116	0.705	4.356	0.296	0.039

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-109	J-145	J-199	105.0	PVC	110.0	22	6.219	0.718	8.494	52.230	3.556	0.465
P-113	J-205	J-206	105.0	PVC	110.0	22	4.582	0.529	4.825	29.668	2.020	0.264
P-114	J-207	J-110	105.0	PVC	110.0	22	1.186	0.137	0.395	2.429	0.165	0.022
P-119	J-109	J-179	105.0	PVC	110.0	22	1.227	0.142	0.420	2.585	0.176	0.023
P-124	J-221	J-222	100.0	CI	70.0	22	1.868	0.238	2.683	16.498	1.123	0.147
P-135	J-111	J-239	150.0	AC	65.0	24	4.123	0.233	1.850	11.373	0.774	0.102
P-141	J-246	J-247	105.0	PVC	110.0	24	0.108	0.012	0.005	0.029	0.002	0.000
P-146	J-255	J-256	105.0	PVC	110.0	24	1.947	0.225	0.989	6.080	0.414	0.054
P-147	J-257	J-258	105.0	PVC	110.0	25	2.017	0.233	1.055	6.488	0.442	0.058
P-159	J-275	J-139	150.0	AC	65.0	25	7.184	0.407	5.174	31.812	2.166	0.283
P-161	J-276	J-277	100.0	AC	65.0	25	3.170	0.404	8.191	50.358	3.428	0.448
P-164	J-282	J-14	100.0	CI	70.0	26	0.287	0.037	0.084	0.514	0.035	0.005
P-177	J-302	J-303	150.0	AC	65.0	26	7.907	0.447	6.179	37.989	2.586	0.338
P-190	J-139	J-318	150.0	AC	65.0	27	8.876	0.502	7.654	47.064	3.204	0.419

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-198	J-325	J-10	105.0	PVC	110.0	28	10.856	1.254	23.837	146.570	9.979	1.305
P-201	J-329	J-330	200.0	CI	70.0	28	6.699	0.213	0.976	5.994	0.408	0.053
P-202	J-331	J-276	250.0	CI	70.0	28	27.952	0.569	4.638	28.508	1.941	0.254
P-210	J-11	J-338	105.0	PVC	110.0	28	3.934	0.454	3.638	22.370	1.523	0.199
P-215	J-342	J-343	105.0	PVC	110.0	34	5.091	0.588	5.863	36.051	2.454	0.321
P-221	J-352	J-282	100.0	CI	70.0	29	3.860	0.492	10.288	63.258	4.307	0.563
P-223	J-15	J-354	100.0	CI	70.0	29	0.509	0.065	0.242	1.486	0.101	0.013
P-225	J-318	J-356	150.0	AC	65.0	35	4.330	0.245	2.025	12.453	0.848	0.111
P-241	J-376	J-377	105.0	PVC	110.0	30	1.607	0.186	0.693	4.261	0.290	0.038
P-244	J-354	J-379	105.0	PVC	110.0	30	0.508	0.059	0.082	0.505	0.034	0.004
P-248	J-59	J-382	100.0	AC	65.0	31	0.906	0.115	0.802	4.971	0.338	0.044
P-250	J-385	J-221	100.0	CI	70.0	31	0.705	0.090	0.441	2.716	0.185	0.024
P-257	J-395	J-396	100.0	CI	70.0	31	1.432	0.182	1.639	10.077	0.686	0.090
P-259	J-397	J-398	105.0	PVC	110.0	31	0.409	0.047	0.055	0.339	0.023	0.003

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-262	J-395	J-137	100.0	CI	70.0	31	0.090	0.011	0.010	0.059	0.004	0.000
P-263	J-57	J-97	150.0	AC	65.0	31	29.916	1.693	72.634	446.619	30.406	3.975
P-264	J-402	J-194	100.0	CI	70.0	31	0.565	0.072	0.293	1.811	0.124	0.016
P-265	J-403	J-404	150.0	AC	65.0	31	1.532	0.087	0.296	1.818	0.124	0.016
P-267	J-58	J-406	100.0	CI	70.0	32	0.400	0.051	0.141	0.951	0.065	0.009
P-270	J-247	J-325	105.0	PVC	110.0	32	5.015	0.579	5.702	35.061	2.387	0.312
P-271	J-410	J-411	200.0	CI	70.0	32	5.540	0.176	0.686	4.221	0.287	0.038
P-272	J-207	J-412	105.0	PVC	110.0	32	0.146	0.017	0.008	0.050	0.003	0.000
P-277	J-331	J-385	100.0	AC	65.0	32	3.377	0.430	9.213	56.682	3.859	0.504
P-280	J-419	J-420	105.0	PVC	110.0	33	2.449	0.283	1.512	9.298	0.633	0.083
P-282	J-222	J-421	100.0	AC	65.0	33	4.607	0.587	16.374	100.707	6.856	0.896
P-283	J-377	J-422	105.0	PVC	110.0	33	2.295	0.265	1.340	8.241	0.561	0.073
P-289	J-422	J-428	105.0	PVC	110.0	33	1.063	0.123	0.322	1.982	0.135	0.018
P-290	J-195	J-138	100.0	CI	70.0	33	1.101	0.140	1.007	6.200	0.422	0.055

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-291	J-429	J-430	105.0	PVC	110.0	33	0.153	0.018	0.009	0.054	0.004	0.001
P-294	J-138	J-432	100.0	CI	70.0	34	0.227	0.029	0.054	0.330	0.022	0.003
P-299	J-437	J-438	105.0	PVC	110.0	34	1.384	0.160	0.526	3.233	0.220	0.029
P-301	J-440	J-441	105.0	PVC	110.0	34	0.553	0.064	0.096	0.590	0.040	0.005
P-307	J-447	J-448	200.0	CI	70.0	35	3.888	0.124	0.356	2.184	0.149	0.019
P-308	J-398	J-419	105.0	PVC	110.0	35	0.949	0.110	0.261	1.607	0.109	0.014
P-309	J-43	J-449	105.0	PVC	110.0	35	5.975	0.690	7.888	48.505	3.302	0.432
P-312	J-420	J-451	100.0	CI	70.0	37	0.672	0.086	0.403	2.481	0.169	0.022
P-319	J-458	J-459	150.0	AC	65.0	35	2.681	0.152	0.834	5.125	0.349	0.046
P-322	J-329	J-410	200.0	CI	70.0	36	16.999	0.541	5.475	33.663	2.292	0.300
P-330	J-473	J-474	150.0	AC	65.0	37	8.451	0.478	6.988	42.971	2.926	0.382
P-340	J-484	J-402	100.0	CI	70.0	36	0.317	0.040	0.098	0.595	0.040	0.005
P-342	J-44	J-430	105.0	PVC	110.0	36	0.139	0.016	0.007	0.045	0.003	0.000
P-344	J-474	J-140	150.0	AC	65.0	36	9.292	0.526	8.331	51.223	3.487	0.456

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-345	J-488	J-489	150.0	AC	65.0	36	7.278	0.412	5.299	32.585	2.218	0.290
P-348	J-493	J-494	105.0	PVC	110.0	37	0.786	0.091	0.185	1.134	0.077	0.010
P-350	J-141	J-497	100.0	AC	65.0	37	1.052	0.134	1.062	6.530	0.445	0.058
P-352	J-500	J-501	105.0	PVC	110.0	37	7.451	0.860	11.871	72.991	4.969	0.650
P-356	J-30	J-342	105.0	PVC	110.0	37	11.308	1.306	25.708	158.074	10.762	1.407
P-358	J-420	J-352	100.0	CI	70.0	37	2.268	0.289	3.843	23.628	1.608	0.210
P-371	J-524	J-356	100.0	AC	65.0	38	5.135	0.654	20.020	123.103	8.381	1.096
P-373	J-303	J-473	150.0	AC	65.0	38	8.819	0.499	7.564	46.506	3.166	0.414
P-376	J-527	J-397	105.0	PVC	110.0	39	2.111	0.244	1.149	7.064	0.481	0.063
P-379	J-448	J-528	100.0	CI	70.0	39	2.122	0.270	3.395	20.909	1.423	0.186
P-387	J-532	J-488	100.0	CI	70.0	39	6.932	0.883	30.423	187.062	12.735	1.665
P-393	J-206	J-56	105.0	PVC	110.0	39	10.963	1.266	24.273	149.256	10.161	1.328
P-401	J-489	J-500	105.0	PVC	110.0	40	3.207	0.370	2.492	15.322	1.043	0.136
P-406	J-551	J-552	105.0	PVC	110.0	40	0.184	0.021	0.012	0.077	0.005	0.001

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-410	J-557	J-558	100.0	CI	70.0	41	2.556	0.325	4.793	29.473	2.006	0.262
P-411	J-497	J-559	100.0	CI	70.0	41	5.236	0.667	18.091	111.236	7.573	0.990
P-415	J-342	J-338	105.0	PVC	110.0	41	5.705	0.659	7.240	44.516	3.030	0.396
P-421	J-184	J-146	46.6	PVC	110.0	41	0.028	0.016	0.019	0.119	0.008	0.001
P-432	J-524	J-318	100.0	AC	65.0	43	5.029	0.640	19.259	118.420	8.062	1.054
P-439	J-583	J-558	150.0	AC	65.0	42	8.240	0.466	6.669	41.009	2.792	0.365
P-441	J-586	J-428	105.0	PVC	110.0	42	0.192	0.022	0.014	0.083	0.006	0.001
P-446	J-30	J-275	150.0	AC	65.0	65	10.330	0.585	10.137	62.331	4.243	0.555
P-450	J-597	J-255	105.0	PVC	110.0	42	3.032	0.350	2.246	13.808	0.940	0.123
P-452	J-527	J-599	150.0	AC	65.0	42	5.044	0.285	2.687	16.523	1.125	0.147
P-462	J-437	J-609	105.0	PVC	110.0	43	1.030	0.119	0.304	1.870	0.127	0.017
P-472	J-623	J-624	150.0	AC	65.0	43	10.253	0.580	9.997	61.446	4.183	0.547
P-478	J-438	J-258	105.0	PVC	110.0	44	2.623	0.303	1.717	10.560	0.719	0.094
P-481	J-634	J-377	105.0	PVC	110.0	44	0.200	0.023	0.015	0.090	0.006	0.001

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-482	J-180	J-635	105.0	PVC	110.0	44	1.185	0.137	0.394	2.424	0.165	0.021
P-483	J-13	J-421	250.0	CI	70.0	44	37.001	0.754	7.796	47.933	3.263	0.427
P-498	J-257	J-647	105.0	PVC	110.0	46	1.693	0.196	0.763	4.692	0.319	0.042
P-500	J-396	J-59	100.0	CI	70.0	44	0.506	0.064	0.239	1.459	0.099	0.013
P-506	J-180	J-647	105.0	PVC	110.0	45	1.276	0.147	0.452	2.779	0.189	0.025
P-513	J-658	J-343	105.0	PVC	110.0	45	0.207	0.024	0.016	0.096	0.006	0.001
P-519	J-205	J-29	105.0	PVC	110.0	59	2.964	0.342	2.153	13.240	0.901	0.118
P-529	J-672	J-459	150.0	AC	65.0	46	7.897	0.447	6.164	37.899	2.580	0.337
P-538	J-98	J-524	100.0	AC	65.0	46	10.750	1.369	78.644	483.575	32.921	4.304
P-548	J-599	J-687	100.0	CI	70.0	47	0.585	0.074	0.312	1.918	0.131	0.017
P-550	J-440	J-403	105.0	PVC	110.0	47	0.678	0.078	0.140	0.861	0.059	0.008
P-551	J-343	J-11	105.0	PVC	110.0	47	4.308	0.498	4.304	26.462	1.802	0.236
P-562	J-404	J-441	105.0	PVC	110.0	47	0.957	0.111	0.265	1.632	0.111	0.015
P-570	J-528	J-700	200.0	AC	65.0	48	4.893	0.156	0.626	3.850	0.262	0.034

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-579	J-421	J-331	250.0	CI	70.0	48	31.824	0.648	5.897	36.255	2.468	0.323
P-581	J-258	J-145	105.0	PVC	110.0	48	5.173	0.597	6.040	37.138	2.528	0.331
P-597	J-256	J-552	105.0	PVC	110.0	49	0.990	0.114	0.283	1.738	0.118	0.015
P-607	J-239	J-275	150.0	AC	65.0	50	3.788	0.214	1.581	9.723	0.662	0.087
P-623	J-430	J-207	105.0	PVC	110.0	50	0.562	0.065	0.099	0.608	0.041	0.005
P-624	J-356	J-725	150.0	AC	65.0	51	0.236	0.013	0.009	0.057	0.004	0.001
P-642	J-623	J-484	100.0	CI	70.0	51	0.560	0.071	0.284	1.747	0.119	0.016
P-644	J-559	J-474	150.0	AC	65.0	51	1.411	0.080	0.254	1.561	0.106	0.014
P-693	J-766	J-557	46.6	PVC	110.0	55	1.678	0.984	39.250	241.343	16.431	2.148
P-719	J-779	J-451	46.6	PVC	110.0	56	0.495	0.290	4.089	25.139	1.712	0.224
P-730	J-179	J-609	105.0	PVC	110.0	65	0.343	0.040	0.040	0.245	0.017	0.002
P-734	J-396	J-195	100.0	CI	70.0	57	0.319	0.041	0.101	0.630	0.043	0.006
P-738	J-784	J-583	150.0	AC	65.0	57	11.817	0.669	13.004	79.959	5.444	0.712
P-743	J-330	J-277	100.0	AC	65.0	58	0.752	0.096	0.570	3.501	0.238	0.031

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-745	J-449	J-583	100.0	AC	65.0	58	4.297	0.547	14.393	88.504	6.025	0.788
P-751	J-194	J-58	100.0	CI	70.0	59	0.166	0.021	0.027	0.186	0.013	0.002
P-754	J-402	J-406	100.0	CI	70.0	59	0.331	0.042	0.107	0.639	0.044	0.006
P-763	J-276	J-329	250.0	CI	70.0	60	24.263	0.494	3.568	21.936	1.493	0.195
P-782	J-609	J-109	105.0	PVC	110.0	63	0.591	0.068	0.108	0.667	0.045	0.006
P-805	J-382	J-447	100.0	AC	65.0	64	0.914	0.116	0.817	5.055	0.344	0.045
P-809	J-140	J-302	150.0	AC	65.0	86	3.316	0.188	1.236	7.599	0.517	0.068
P-826	J-552	J-494	46.6	PVC	110.0	66	0.095	0.056	0.193	1.186	0.081	0.011
P-827	J-428	J-493	105.0	PVC	110.0	66	1.903	0.220	0.948	5.827	0.397	0.052
P-842	J-819	J-303	150.0	AC	65.0	67	0.308	0.017	0.015	0.093	0.006	0.001
P-848	J-559	J-672	100.0	CI	70.0	68	7.378	0.939	34.145	209.950	14.293	1.869
P-853	J-824	J-497	100.0	CI	70.0	68	5.622	0.716	20.637	126.894	8.639	1.129
P-861	J-379	J-338	46.6	PVC	110.0	69	1.140	0.668	19.177	117.913	8.028	1.049
P-896	J-14	J-779	105.0	PVC	110.0	73	3.385	0.391	2.753	16.928	1.152	0.151

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-903	J-687	J-352	100.0	CI	70.0	74	0.949	0.121	0.766	4.707	0.320	0.042
P-922	J-484	J-432	100.0	CI	70.0	76	0.993	0.126	0.832	5.125	0.349	0.046
P-945	J-599	J-532	150.0	AC	65.0	78	6.395	0.362	4.171	25.644	1.746	0.228
P-958	J-494	J-256	46.6	PVC	110.0	113	0.106	0.062	0.235	1.448	0.098	0.013
P-961	J-458	J-473	150.0	AC	65.0	82	17.987	1.018	28.313	174.086	11.852	1.549
P-968	J-137	J-221	100.0	CI	70.0	82	1.955	0.249	2.918	17.953	1.222	0.160
P-971	J-385	J-395	100.0	CI	70.0	83	2.005	0.255	3.059	18.816	1.281	0.167
P-975	J-15	J-325	105.0	PVC	110.0	83	5.190	0.599	6.076	37.361	2.543	0.333
P-977	J-98	J-12	250.0	CI	70.0	83	48.288	0.984	12.765	78.491	5.344	0.699
P-979	J-13	J-852	250.0	CI	70.0	83	28.038	0.571	4.664	28.684	1.953	0.255
P-981	J-459	J-624	150.0	AC	65.0	83	11.331	0.641	12.030	73.965	5.035	0.658
P-982	J-432	J-222	100.0	AC	65.0	83	2.105	0.268	3.837	23.607	1.607	0.210
P-983	J-779	J-422	105.0	PVC	110.0	83	1.915	0.221	0.959	5.898	0.402	0.052
P-986	J-302	J-111	150.0	AC	65.0	96	3.633	0.206	1.464	8.999	0.613	0.080

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-987	J-852	J-623	150.0	AC	65.0	85	10.514	0.595	10.473	64.422	4.386	0.573
P-988	J-493	J-354	105.0	PVC	110.0	85	3.549	0.410	3.006	18.482	1.258	0.164
P-989	J-500	J-10	105.0	PVC	110.0	85	3.502	0.404	2.933	18.034	1.228	0.160
P-992	J-180	J-438	105.0	PVC	110.0	86	0.491	0.057	0.077	0.474	0.032	0.004
P-996	J-97	J-144	100.0	AC	65.0	87	6.354	0.809	29.703	182.638	12.434	1.625
P-1008	J-282	J-247	105.0	PVC	110.0	90	4.239	0.490	4.176	25.679	1.748	0.229
P-1015	J-184	J-29	46.6	PVC	110.0	92	0.769	0.451	9.248	56.864	3.871	0.506
P-1026	J-451	J-376	100.0	CI	70.0	94	1.037	0.132	0.902	5.549	0.378	0.049
P-1027	J-146	J-205	46.6	PVC	110.0	95	0.815	0.478	10.313	63.415	4.317	0.564
P-1032	J-862	J-766	46.6	PVC	110.0	127	0.582	0.341	5.518	33.929	2.310	0.302
P-1039	J-489	J-824	150.0	AC	65.0	97	4.866	0.275	2.514	15.457	1.052	0.138
P-1046	J-852	J-458	150.0	AC	65.0	100	16.299	0.922	23.588	145.045	9.875	1.291
P-1047	J-766	J-255	105.0	PVC	110.0	114	0.258	0.030	0.023	0.144	0.010	0.001
P-1052	J-379	J-863	46.6	PVC	110.0	131	0.598	0.351	5.806	35.698	2.430	0.318

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1065	J-687	J-866	105.0	PVC	110.0	107	0.491	0.057	0.077	0.474	0.032	0.004
P-1077	J-597	J-784	150.0	AC	65.0	153	9.037	0.511	7.914	48.659	3.313	0.433
P-1090	J-406	J-448	100.0	CI	70.0	118	0.888	0.113	0.657	4.091	0.278	0.036
P-1095	J-144	J-871	100.0	AC	65.0	119	6.469	0.824	30.708	188.825	12.855	1.681
P-1096	J-501	J-141	100.0	AC	65.0	120	3.448	0.439	9.576	58.881	4.009	0.524
P-1100	J-501	J-140	105.0	PVC	110.0	212	5.692	0.657	7.210	44.332	3.018	0.395
P-1105	J-871	J-410	200.0	CI	70.0	125	10.578	0.337	2.274	13.983	0.952	0.124
P-1107	J-199	J-635	105.0	PVC	110.0	153	2.088	0.241	1.125	6.917	0.471	0.062
P-1108	J-354	J-557	100.0	CI	70.0	126	4.784	0.609	15.310	94.138	6.409	0.838
P-1112	J-558	J-56	150.0	AC	65.0	127	11.756	0.665	12.880	79.195	5.392	0.705
P-1116	J-557	J-206	105.0	PVC	110.0	129	5.509	0.636	6.786	41.726	2.841	0.371
P-1119	J-44	J-199	105.0	PVC	110.0	131	2.730	0.315	1.850	11.373	0.774	0.101
P-1122	J-441	J-419	105.0	PVC	110.0	133	0.580	0.067	0.105	0.646	0.044	0.006
P-1129	J-876	J-449	100.0	AC	65.0	137	0.626	0.080	0.407	2.501	0.170	0.022

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-1131	J-398	J-440	105.0	PVC	110.0	138	0.426	0.049	0.059	0.364	0.025	0.003
P-1135	J-397	J-440	105.0	PVC	110.0	222	0.364	0.042	0.044	0.273	0.019	0.002
P-1159	J-880	J-784	100.0	CI	70.0	198	0.908	0.116	0.705	4.337	0.295	0.039
P-1162	J-57	J-43	105.0	PVC	110.0	199	5.292	0.611	6.299	38.732	2.637	0.345
P-1170	J-277	J-382	100.0	AC	65.0	176	1.231	0.157	1.421	8.744	0.595	0.078
P-1179	J-527	J-403	150.0	AC	65.0	334	1.033	0.058	0.143	0.877	0.060	0.008
P-1180	J-330	J-447	200.0	CI	70.0	197	6.158	0.196	0.835	5.127	0.349	0.046
P-1187	J-411	J-528	200.0	AC	65.0	243	4.281	0.136	0.488	3.003	0.204	0.027
P-1190	J-404	J-597	150.0	AC	65.0	247	3.981	0.225	1.733	10.658	0.726	0.095
P-1193	J-884	J-871	200.0	CI	70.0	327	1.495	0.048	0.061	0.373	0.025	0.003
P-1194	J-624	J-700	150.0	AC	65.0	330	3.166	0.179	1.134	6.981	0.475	0.062

Node/ Junction results for Vastu Khand DMA

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-10	121.25	0.530	133.92	12.65	-32.98	17.80	21.02
J-11	121.36	0.359	133.96	12.58	-32.83	17.70	20.91
J-12	119.56	0.537	141.86	22.25	17.41	22.80	23.14
J-13	119.43	0.603	141.76	22.28	16.91	22.88	23.26
J-14	118.15	0.474	132.71	14.53	-37.33	20.39	24.05
J-15	118.18	0.535	132.76	14.56	-37.03	20.38	24.03
J-29	121.41	0.719	135.32	13.89	-24.53	18.22	20.94
J-30	121.51	0.499	135.32	13.79	-24.65	18.13	20.84
J-43	118.93	1.107	135.71	16.74	-19.71	20.86	23.43
J-44	119.42	0.802	135.71	16.26	-20.16	20.37	22.94
J-56	120.75	0.807	136.51	15.74	-16.56	19.38	21.67
J-57	120.83	1.098	136.96	16.09	-13.92	19.48	21.60
J-58	117.82	0.458	140.51	22.64	10.87	23.97	24.80
J-59	118.01	0.388	140.52	22.46	10.74	23.78	24.61
J-60	121.45	0.136	136.11	14.63	-19.75	18.51	20.94
J-61	121.21	0.124	136.11	14.86	-19.52	18.75	21.18
J-97	121.00	0.610	139.24	18.20	-0.11	20.26	21.56
J-98	121.00	0.658	140.80	19.75	9.47	20.92	21.64
J-109	120.99	0.459	135.73	14.72	-21.59	18.82	21.38
J-110	120.94	0.173	135.73	14.76	-21.59	18.86	21.43
J-111	120.47	0.620	136.11	15.61	-18.80	19.49	21.92
J-137	118.35	0.600	140.58	22.19	10.78	23.48	24.28
J-138	118.23	0.390	140.56	22.28	10.75	23.58	24.40
J-139	121.47	0.322	136.11	14.62	-19.74	18.50	20.92
J-140	114.06	1.616	136.14	22.04	-12.19	25.90	28.32
J-141	113.76	0.800	135.76	21.95	-14.23	26.04	28.60
J-144	120.62	1.029	136.64	15.99	-15.66	19.56	21.80
J-145	121.03	0.403	136.14	15.07	-19.15	18.94	21.36
J-146	119.86	0.705	134.47	14.59	-28.20	19.42	22.44
J-147	119.63	0.083	134.47	14.81	-27.99	19.64	22.67
J-179	121.00	0.491	135.74	14.71	-21.54	18.81	21.37
J-180	121.00	0.891	135.77	14.74	-21.41	18.82	21.37
J-183	119.87	0.093	134.47	14.57	-28.24	19.41	22.43
J-184	120.11	0.703	134.47	14.34	-28.45	19.17	22.19
J-194	117.29	0.509	140.51	23.17	11.39	24.50	25.33
J-195	117.90	0.511	140.52	22.58	10.88	23.90	24.73
J-199	121.25	1.401	135.96	14.68	-20.49	18.65	21.14
J-205	120.52	0.803	135.45	14.90	-22.86	19.17	21.84

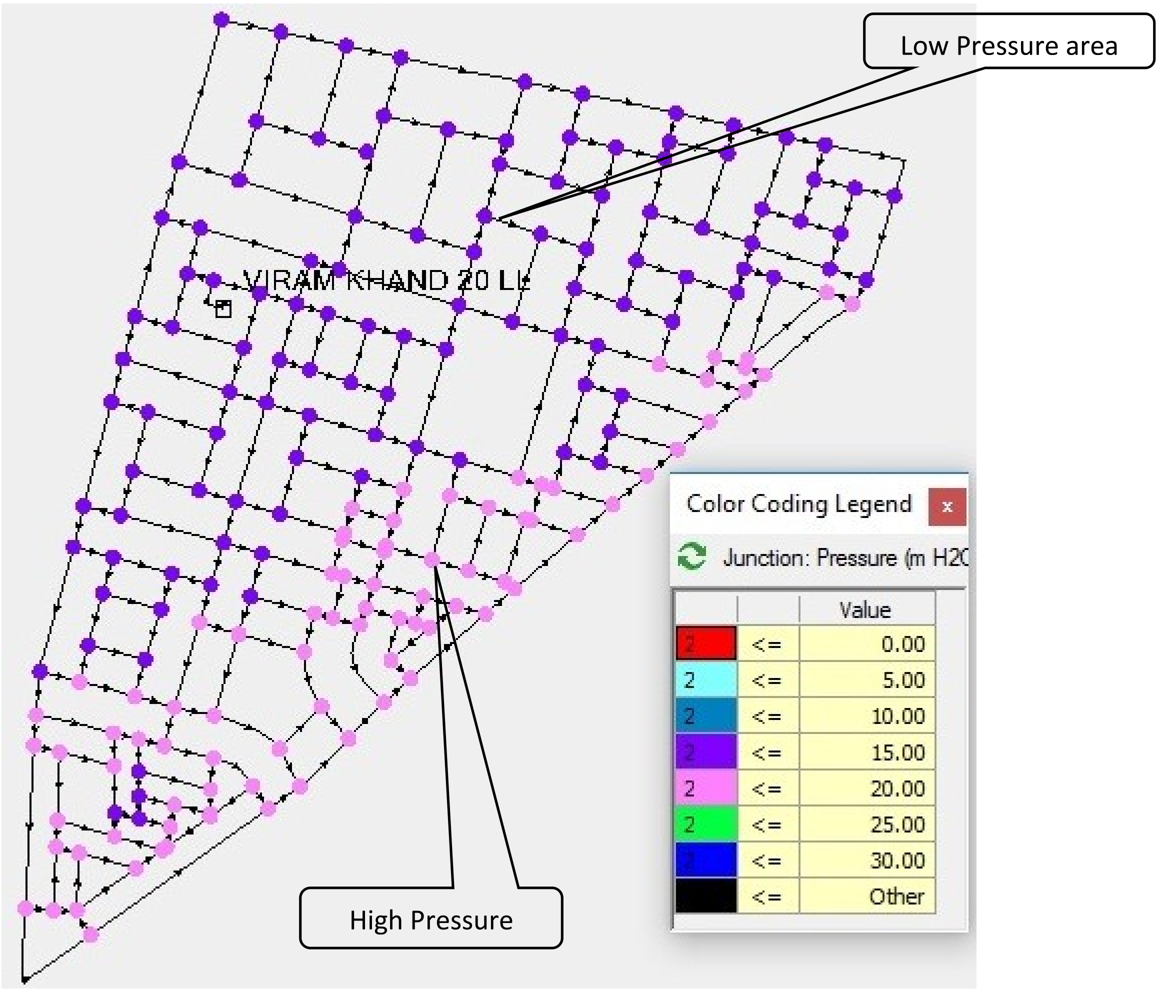
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-206	120.01	0.872	135.56	15.52	-21.70	19.72	22.35
J-207	120.82	0.478	135.72	14.86	-21.53	18.97	21.54
J-221	119.08	0.618	140.82	21.70	11.52	22.84	23.56
J-222	118.80	0.634	140.88	22.04	12.17	23.15	23.85
J-239	121.03	0.335	136.06	15.00	-19.62	18.91	21.36
J-246	120.57	0.108	133.08	12.49	-37.44	18.13	21.66
J-247	121.45	0.668	133.08	11.61	-38.32	17.25	20.78
J-255	116.77	0.827	132.54	15.75	-36.96	21.70	25.42
J-256	117.50	0.851	132.52	14.99	-37.84	20.96	24.69
J-257	120.71	0.324	135.82	15.09	-20.77	19.14	21.67
J-258	120.11	0.533	135.85	15.71	-20.02	19.74	22.27
J-275	121.32	0.642	135.98	14.64	-20.39	18.59	21.07
J-276	120.00	0.519	141.00	20.96	11.72	22.00	22.65
J-277	119.80	1.187	140.79	20.95	10.64	22.12	22.85
J-282	118.11	0.666	132.71	14.57	-37.30	20.43	24.09
J-302	117.98	0.958	136.25	18.23	-15.45	22.03	24.41
J-303	118.51	0.604	136.41	17.87	-14.97	21.58	23.90
J-318	121.60	0.482	136.32	14.70	-18.59	18.45	20.81
J-325	121.57	0.652	133.26	11.67	-37.33	17.20	20.66
J-329	120.21	0.565	140.79	20.54	10.20	21.71	22.44
J-330	120.59	1.293	140.76	20.13	9.65	21.31	22.05
J-331	119.80	0.495	141.13	21.29	12.71	22.26	22.86
J-338	121.86	0.631	134.07	12.18	-32.70	17.25	20.42
J-342	121.48	0.513	134.36	12.86	-30.50	17.75	20.82
J-343	120.59	0.576	134.16	13.55	-30.83	18.56	21.69
J-352	118.39	0.643	132.40	13.98	-39.43	20.02	23.79
J-354	118.81	1.237	132.75	13.92	-37.70	19.75	23.40
J-356	121.59	0.570	136.39	14.77	-18.15	18.49	20.82
J-376	119.26	0.570	132.36	13.07	-40.57	19.13	22.92
J-377	119.34	0.488	132.38	13.02	-40.52	19.06	22.84
J-379	119.23	1.050	132.75	13.49	-38.14	19.32	22.97
J-382	118.61	1.240	140.54	21.89	10.29	23.20	24.02
J-385	119.40	0.667	140.83	21.39	11.28	22.53	23.24
J-395	118.76	0.664	140.58	21.78	10.37	23.07	23.87
J-396	118.62	0.607	140.53	21.86	10.19	23.18	24.01
J-397	115.66	1.338	132.20	16.51	-37.94	22.66	26.50
J-398	116.80	0.933	132.20	15.37	-39.09	21.52	25.37
J-402	116.38	0.579	140.50	24.07	12.25	25.41	26.25
J-403	118.03	1.888	132.20	14.14	-40.32	20.29	24.14

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-404	118.14	1.491	132.21	14.04	-40.37	20.19	24.03
J-406	117.00	0.957	140.51	23.46	11.66	24.79	25.62
J-410	119.81	0.882	140.59	20.75	9.40	22.03	22.83
J-411	120.75	1.259	140.57	19.78	8.32	21.07	21.88
J-412	120.58	0.146	135.72	15.10	-21.29	19.21	21.78
J-419	118.23	0.920	132.21	13.95	-40.46	20.10	23.94
J-420	118.78	0.491	132.26	13.46	-40.70	19.57	23.40
J-421	119.43	0.571	141.41	21.94	14.82	22.74	23.25
J-422	119.18	0.684	132.43	13.22	-40.09	19.24	23.01
J-428	119.06	0.648	132.44	13.35	-39.90	19.36	23.13
J-429	120.28	0.153	135.71	15.40	-21.02	19.52	22.09
J-430	120.80	0.548	135.71	14.88	-21.53	18.99	21.57
J-432	118.08	0.885	140.56	22.43	10.92	23.73	24.55
J-437	121.00	0.354	135.75	14.72	-21.48	18.81	21.37
J-438	120.32	0.748	135.77	15.42	-20.69	19.50	22.05
J-440	118.81	2.020	132.19	13.36	-41.14	19.52	23.37
J-441	119.04	0.985	132.20	13.13	-41.35	19.28	23.13
J-447	118.92	1.355	140.60	21.63	10.31	22.91	23.71
J-448	117.86	0.879	140.58	22.68	11.29	23.97	24.77
J-449	118.60	1.052	135.43	16.80	-21.07	21.07	23.75
J-451	119.97	0.860	132.28	12.28	-41.80	18.38	22.21
J-458	117.17	0.993	139.02	21.80	2.35	23.99	25.37
J-459	116.37	0.753	139.04	22.63	3.33	24.81	26.17
J-473	116.75	0.717	136.70	19.90	-11.45	23.44	25.66
J-474	115.42	0.570	136.44	20.98	-11.68	24.67	26.98
J-484	116.21	0.749	140.50	24.24	12.39	25.57	26.41
J-488	119.40	0.346	133.88	14.45	-31.40	19.63	22.87
J-489	119.27	0.795	134.07	14.78	-30.08	19.84	23.01
J-493	119.79	0.860	132.50	12.69	-40.24	18.66	22.41
J-494	119.17	0.987	132.49	13.30	-39.67	19.28	23.02
J-497	114.18	0.666	135.72	21.49	-14.89	25.60	28.17
J-500	119.00	0.741	134.17	15.14	-29.20	20.15	23.28
J-501	117.01	1.690	134.61	17.57	-24.52	22.32	25.29
J-524	121.45	0.586	137.16	15.68	-13.31	18.95	21.00
J-527	115.26	1.899	132.25	16.95	-37.27	23.08	26.91
J-528	117.38	1.509	140.45	23.03	10.96	24.39	25.24
J-532	117.90	0.537	132.69	14.76	-37.20	20.62	24.30
J-551	119.67	0.184	132.50	12.81	-40.09	18.79	22.53
J-552	118.66	0.711	132.51	13.82	-39.08	19.79	23.53

Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	As per present supply hours Pressure (m H2O)	Pressure (m H2O) 3 hours supply	Pressure (m H2O) 8 hours supply	Pressure (m H2O) 24 hours supply
J-557	118.13	1.602	134.68	16.51	-25.21	21.23	24.17
J-558	116.93	0.960	134.88	17.91	-22.81	22.51	25.39
J-559	115.37	0.731	136.46	21.04	-11.56	24.72	27.03
J-583	115.82	0.720	134.60	18.74	-23.42	23.50	26.48
J-586	119.33	0.192	132.44	13.08	-40.18	19.09	22.85
J-597	116.72	2.025	132.64	15.88	-36.34	21.78	25.47
J-599	115.53	0.767	132.36	16.79	-36.84	22.85	26.64
J-609	121.08	0.783	135.74	14.63	-21.64	18.73	21.29
J-623	116.52	0.821	140.48	23.91	11.99	25.26	26.10
J-624	115.00	2.088	140.05	25.00	10.86	26.60	27.60
J-634	118.39	0.200	132.38	13.97	-39.57	20.01	23.80
J-635	120.98	0.903	135.78	14.78	-21.28	18.85	21.40
J-647	121.00	0.417	135.79	14.76	-21.28	18.83	21.37
J-658	121.03	0.207	134.16	13.11	-31.27	18.12	21.26
J-672	116.57	0.519	138.76	22.15	1.40	24.49	25.96
J-687	117.26	1.043	132.35	15.05	-38.66	21.12	24.91
J-700	115.46	1.727	140.42	24.92	12.70	26.30	27.16
J-725	120.31	0.236	136.39	16.05	-16.88	19.77	22.10
J-766	117.33	1.354	132.54	15.18	-37.54	21.13	24.86
J-779	120.10	0.975	132.51	12.38	-40.52	18.35	22.09
J-784	118.02	1.872	133.85	15.80	-30.19	20.99	24.24
J-819	120.23	0.308	136.41	16.14	-16.70	19.85	22.17
J-824	112.61	0.756	134.32	21.66	-21.94	26.58	29.66
J-852	118.22	1.225	141.37	23.10	15.73	23.93	24.45
J-862	119.33	0.582	131.84	12.48	-43.84	18.84	22.82
J-863	121.81	0.598	131.99	10.16	-45.37	16.43	20.35
J-866	120.01	0.491	132.34	12.31	-41.45	18.38	22.18
J-871	119.87	2.614	140.31	20.39	7.59	21.84	22.74
J-876	120.86	0.626	135.38	14.48	-23.67	18.79	21.49
J-880	120.48	0.908	133.71	13.21	-33.50	18.48	21.78
J-884	117.99	1.495	140.29	22.25	9.35	23.71	24.62

Viram Khand DMA

In case of Viram Khand DMA, the total flow through this DMA is 2.35 MLD. This demand is applied to that DMA. As the supply for this DMA is for 5 hours, the peak factor is 4.8.



The results of calibration are presented in table below:

Pipe results for Viram Khand DMA

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-7	J-8	J-9	100.0	AC	65.0	3	0.085	0.011	0.009	0.062	0.003	0.000
P-14	J-22	J-23	150.0	AC	65.0	6	0.417	0.024	0.027	0.163	0.011	0.002
P-19	J-31	J-32	150.0	AC	65.0	6	1.238	0.070	0.199	1.226	0.084	0.010
P-22	J-37	J-38	100.0	AC	65.0	7	0.575	0.073	0.346	2.132	0.144	0.019
P-24	J-41	J-42	150.0	AC	65.0	8	5.657	0.320	3.322	20.438	1.391	0.183
P-27	J-47	J-48	150.0	AC	65.0	9	0.886	0.050	0.106	0.648	0.045	0.006
P-49	J-89	J-90	100.0	AC	65.0	14	0.144	0.018	0.027	0.165	0.011	0.002
P-51	J-93	J-94	150.0	AC	65.0	14	5.616	0.318	3.279	20.168	1.373	0.180
P-52	J-95	J-96	150.0	AC	65.0	14	2.816	0.159	0.913	5.617	0.382	0.050
P-67	J-122	J-123	100.0	AC	65.0	17	1.074	0.137	1.105	6.793	0.462	0.060
P-83	J-152	J-122	100.0	AC	65.0	19	0.532	0.068	0.300	1.848	0.126	0.017
P-94	J-171	J-172	152.6	PVC	110.0	20	1.220	0.067	0.067	0.414	0.028	0.003
P-95	J-173	J-174	100.0	AC	65.0	20	0.669	0.085	0.459	2.825	0.192	0.025
P-111	J-202	J-203	100.0	AC	65.0	22	0.689	0.088	0.486	2.986	0.203	0.026
P-133	J-23	J-237	100.0	AC	65.0	23	0.250	0.032	0.074	0.461	0.032	0.004
P-134	J-48	J-238	150.0	AC	65.0	23	1.377	0.078	0.243	1.501	0.102	0.013
P-148	J-237	J-259	100.0	AC	65.0	25	0.049	0.006	0.004	0.025	0.002	0.000
P-155	J-269	J-270	100.0	AC	65.0	25	0.110	0.014	0.015	0.102	0.007	0.001
P-162	J-278	J-279	100.0	AC	65.0	26	0.505	0.064	0.273	1.679	0.114	0.015
P-168	J-289	J-290	105.0	PVC	110.0	26	0.145	0.017	0.008	0.053	0.004	0.000
P-175	J-299	J-300	100.0	AC	65.0	26	0.171	0.022	0.037	0.224	0.016	0.002
P-183	J-310	J-311	100.0	AC	65.0	27	0.278	0.035	0.090	0.557	0.038	0.005
P-186	J-314	J-95	150.0	AC	65.0	27	3.356	0.190	1.264	7.773	0.529	0.069
P-189	J-9	J-317	100.0	AC	65.0	27	0.385	0.049	0.165	1.017	0.069	0.009

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-196	J-322	J-323	150.0	AC	65.0	27	2.022	0.114	0.494	3.041	0.207	0.027
P-200	J-327	J-328	105.0	PVC	110.0	28	0.121	0.014	0.001	0.028	0.002	0.000
P-205	J-334	J-238	250.0	AC	65.0	28	3.396	0.069	0.107	0.659	0.045	0.006
P-208	J-310	J-270	100.0	AC	65.0	28	0.337	0.043	0.129	0.794	0.054	0.007
P-209	J-337	J-269	100.0	AC	65.0	28	0.612	0.078	0.389	2.393	0.163	0.021
P-211	J-42	J-339	150.0	AC	65.0	28	0.813	0.046	0.092	0.563	0.038	0.005
P-212	J-340	J-173	100.0	AC	65.0	28	2.710	0.345	6.130	37.700	2.567	0.335
P-217	J-345	J-346	150.0	AC	65.0	29	2.133	0.121	0.546	3.358	0.229	0.030
P-228	J-328	J-360	105.0	PVC	110.0	30	0.950	0.110	0.262	1.575	0.108	0.014
P-230	J-32	J-361	150.0	AC	65.0	30	3.969	0.225	1.724	10.603	0.722	0.094
P-231	J-346	J-362	150.0	AC	65.0	30	0.384	0.022	0.023	0.140	0.009	0.001
P-232	J-363	J-299	100.0	AC	65.0	30	0.070	0.009	0.007	0.043	0.003	0.000
P-233	J-364	J-365	100.0	AC	65.0	30	2.187	0.278	4.121	25.343	1.725	0.225
P-236	J-368	J-369	100.0	AC	65.0	30	0.588	0.075	0.362	2.229	0.152	0.020
P-240	J-374	J-375	300.0	CI	70.0	30	70.104	0.992	10.475	64.426	4.387	0.574
P-249	J-383	J-384	150.0	AC	65.0	31	0.336	0.019	0.018	0.109	0.008	0.001
P-253	J-390	J-391	250.0	AC	65.0	31	0.325	0.007	0.001	0.009	0.001	0.000
P-256	J-122	J-394	100.0	AC	65.0	31	0.790	0.101	0.625	3.847	0.262	0.034
P-258	J-203	J-174	100.0	AC	65.0	31	1.059	0.135	1.075	6.613	0.450	0.059
P-266	J-390	J-405	150.0	AC	65.0	33	0.964	0.055	0.125	0.781	0.053	0.007
P-268	J-407	J-408	152.6	PVC	110.0	32	0.127	0.007	0.001	0.006	0.000	0.000
P-269	J-409	J-279	150.0	AC	65.0	33	2.155	0.122	0.556	3.423	0.233	0.030
P-275	J-278	J-416	100.0	AC	65.0	32	1.565	0.199	2.218	13.642	0.929	0.121
P-286	J-425	J-426	250.0	CI	70.0	33	10.706	0.239	0.426	2.621	0.178	0.023
P-287	J-427	J-171	152.6	PVC	110.0	33	3.988	0.218	0.604	3.714	0.253	0.033

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-293	VIRAM KHAND 20 LL	J-375	300.0	CI	70.0	47	130.556	1.847	33.137	203.800	13.876	1.814
P-295	J-433	J-434	100.0	AC	65.0	34	0.990	0.126	0.950	5.842	0.398	0.052
P-298	J-436	J-364	300.0	CI	70.0	34	17.167	0.243	0.773	4.758	0.324	0.042
P-300	J-328	J-439	150.0	AC	65.0	34	0.488	0.028	0.034	0.220	0.015	0.002
P-303	J-94	J-340	150.0	AC	65.0	35	3.129	0.177	1.110	6.826	0.465	0.061
P-311	J-290	J-48	150.0	AC	65.0	35	0.240	0.014	0.008	0.064	0.004	0.001
P-316	J-317	J-454	100.0	AC	65.0	35	0.691	0.088	0.488	3.003	0.204	0.027
P-317	J-455	J-456	250.0	CI	70.0	35	11.639	0.237	0.916	5.630	0.383	0.050
P-324	J-346	J-337	100.0	AC	65.0	36	1.397	0.178	1.797	11.051	0.752	0.099
P-338	J-483	J-22	150.0	AC	65.0	36	0.798	0.045	0.088	0.543	0.037	0.005
P-339	J-270	J-237	100.0	AC	65.0	36	0.113	0.014	0.017	0.107	0.007	0.001
P-341	J-485	J-486	150.0	AC	65.0	36	6.125	0.347	3.851	23.684	1.613	0.211
P-346	J-345	J-490	100.0	AC	65.0	37	1.003	0.128	0.973	5.984	0.408	0.053
P-349	J-495	J-496	105.0	PVC	110.0	37	0.492	0.057	0.077	0.477	0.033	0.004
P-353	J-361	J-502	150.0	AC	65.0	37	2.975	0.168	1.011	6.216	0.423	0.056
P-361	J-339	J-513	150.0	AC	65.0	38	2.665	0.151	0.825	5.072	0.345	0.045
P-378	J-340	J-31	150.0	AC	65.0	39	2.509	0.142	0.738	4.536	0.309	0.040
P-380	J-433	J-123	100.0	AC	65.0	39	0.333	0.042	0.126	0.777	0.053	0.007
P-381	J-394	J-433	100.0	AC	65.0	39	1.073	0.137	1.102	6.780	0.462	0.060
P-392	J-173	J-152	100.0	AC	65.0	39	1.714	0.218	2.625	16.145	1.099	0.144
P-395	J-360	J-539	152.6	PVC	110.0	40	0.799	0.044	0.031	0.187	0.013	0.002
P-396	J-93	J-41	150.0	AC	65.0	40	3.678	0.208	1.497	9.208	0.627	0.082
P-403	J-546	J-368	300.0	CI	70.0	40	7.772	0.110	0.178	1.097	0.075	0.010
P-412	J-560	J-561	152.6	PVC	110.0	41	1.609	0.088	0.112	0.691	0.047	0.006

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-417	J-269	J-259	100.0	AC	65.0	41	0.149	0.019	0.026	0.171	0.012	0.001
P-424	J-571	J-572	105.0	PVC	110.0	41	0.126	0.015	0.004	0.036	0.002	0.000
P-425	J-573	J-574	100.0	AC	65.0	41	1.721	0.219	2.644	16.259	1.107	0.145
P-428	J-96	J-576	105.0	PVC	110.0	41	1.404	0.162	0.540	3.321	0.226	0.030
P-429	J-259	J-9	100.0	AC	65.0	41	0.203	0.026	0.049	0.308	0.021	0.003
P-433	J-577	J-578	150.0	AC	65.0	42	5.021	0.284	2.664	16.385	1.116	0.146
P-434	J-576	J-495	105.0	PVC	110.0	42	0.330	0.038	0.037	0.228	0.015	0.002
P-436	J-579	J-580	150.0	AC	65.0	42	4.945	0.280	2.591	15.933	1.085	0.142
P-438	J-582	J-1	100.0	AC	65.0	42	0.044	0.006	0.003	0.019	0.001	0.000
P-440	J-584	J-585	100.0	AC	65.0	42	1.593	0.203	2.291	14.090	0.959	0.125
P-442	J-38	J-95	100.0	AC	65.0	42	0.230	0.029	0.064	0.392	0.027	0.003
P-444	J-589	J-590	100.0	AC	65.0	42	1.871	0.238	3.084	18.971	1.292	0.169
P-445	J-591	J-592	100.0	AC	65.0	42	1.240	0.158	1.440	8.860	0.603	0.079
P-447	J-571	J-391	105.0	PVC	110.0	42	0.141	0.016	0.007	0.046	0.003	0.000
P-448	J-593	J-594	250.0	CI	70.0	42	7.909	0.177	0.243	1.496	0.102	0.013
P-449	J-595	J-596	200.0	AC	65.0	42	3.059	0.097	0.262	1.612	0.110	0.015
P-453	J-600	J-37	100.0	AC	65.0	42	0.856	0.109	0.725	4.458	0.304	0.039
P-455	J-496	J-601	105.0	PVC	110.0	43	0.326	0.038	0.036	0.221	0.015	0.002
P-456	J-602	J-601	105.0	PVC	110.0	43	0.146	0.017	0.008	0.050	0.003	0.000
P-457	J-603	J-604	150.0	AC	65.0	43	5.756	0.326	3.432	21.107	1.437	0.188
P-458	J-90	J-605	100.0	AC	65.0	43	0.815	0.104	0.662	4.075	0.277	0.036
P-459	J-606	J-605	100.0	AC	65.0	43	1.490	0.190	2.025	12.454	0.848	0.111
P-466	J-615	J-616	250.0	CI	70.0	43	10.528	0.214	0.760	4.676	0.318	0.042
P-468	J-617	J-485	300.0	CI	70.0	43	35.524	0.503	2.975	18.295	1.246	0.163
P-469	J-618	J-619	300.0	CI	70.0	43	1.050	0.015	0.004	0.027	0.002	0.000

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-471	J-621	J-622	100.0	AC	65.0	43	0.990	0.126	0.949	5.835	0.397	0.052
P-473	J-384	J-625	300.0	CI	70.0	43	6.336	0.090	0.122	0.751	0.051	0.007
P-474	J-434	J-89	300.0	CI	70.0	43	7.976	0.113	0.187	1.151	0.078	0.010
P-480	J-632	J-633	250.0	CI	70.0	44	22.739	0.509	1.720	10.578	0.720	0.094
P-487	J-637	J-638	150.0	AC	65.0	44	5.580	0.316	3.240	19.926	1.357	0.177
P-488	J-289	J-334	100.0	AC	65.0	44	0.426	0.054	0.199	1.237	0.084	0.011
P-490	J-639	J-561	250.0	AC	65.0	44	4.805	0.098	0.204	1.256	0.085	0.011
P-493	J-640	J-641	250.0	CI	70.0	44	26.374	0.590	2.263	13.920	0.948	0.124
P-494	J-642	J-643	100.0	AC	65.0	44	0.992	0.126	0.953	5.861	0.399	0.052
P-495	J-644	J-645	150.0	AC	65.0	44	5.544	0.314	3.201	19.688	1.341	0.175
P-499	J-362	J-648	150.0	AC	65.0	44	2.926	0.166	0.980	6.028	0.411	0.054
P-505	J-585	J-638	150.0	AC	65.0	45	0.063	0.004	0.001	0.005	0.000	0.000
P-507	J-652	J-653	105.0	PVC	110.0	45	0.232	0.027	0.019	0.113	0.007	0.001
P-511	J-202	J-657	100.0	AC	65.0	45	0.990	0.126	0.950	5.844	0.398	0.052
P-515	J-660	J-661	300.0	CI	70.0	45	6.328	0.090	0.122	0.749	0.051	0.007
P-516	J-539	J-662	105.0	PVC	110.0	45	0.392	0.045	0.051	0.317	0.021	0.003
P-523	J-667	J-582	150.0	AC	65.0	45	3.361	0.190	1.267	7.793	0.531	0.069
P-526	J-637	J-643	100.0	AC	65.0	46	1.574	0.200	2.241	13.781	0.939	0.123
P-527	J-602	J-592	105.0	PVC	110.0	46	0.307	0.036	0.032	0.200	0.014	0.002
P-531	J-573	J-600	100.0	AC	65.0	46	1.385	0.176	1.769	10.882	0.741	0.097
P-534	J-674	J-590	150.0	AC	65.0	46	4.567	0.258	2.236	13.749	0.936	0.122
P-535	J-648	J-675	150.0	AC	65.0	46	2.664	0.151	0.824	5.068	0.345	0.045
P-537	J-621	J-648	150.0	AC	65.0	46	3.168	0.179	1.136	6.986	0.476	0.062
P-539	J-676	J-677	105.0	PVC	110.0	46	2.330	0.269	1.378	8.478	0.577	0.075
P-547	J-685	J-686	100.0	AC	65.0	47	0.691	0.088	0.488	3.000	0.204	0.027

Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Flow (L/s)	Velocity (m/s)	As per present supply hours Headloss Gradient (m/km)	Headloss Gradient (m/km) 3 hours supply	Headloss Gradient (m/km) 8 hours supply	Headloss Gradient (m/km) 24 hours supply
P-552	J-560	J-652	105.0	PVC	110.0	47	0.493	0.057	0.078	0.478	0.032	0.004
P-556	J-662	J-572	105.0	PVC	110.0	47	0.471	0.054	0.071	0.442	0.030	0.004
P-558	J-603	J-674	300.0	CI	70.0	47	31.229	0.442	2.343	14.411	0.981	0.128
P-559	J-692	J-625	150.0	AC	65.0	47	1.617	0.092	0.327	2.011	0.137	0.018
P-560	J-661	J-693	300.0	CI	70.0	47	5.271	0.075	0.087	0.534	0.036	0.005
P-564	J-486	J-579	150.0	AC	65.0	47	4.093	0.232	1.825	11.222	0.764	0.100

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