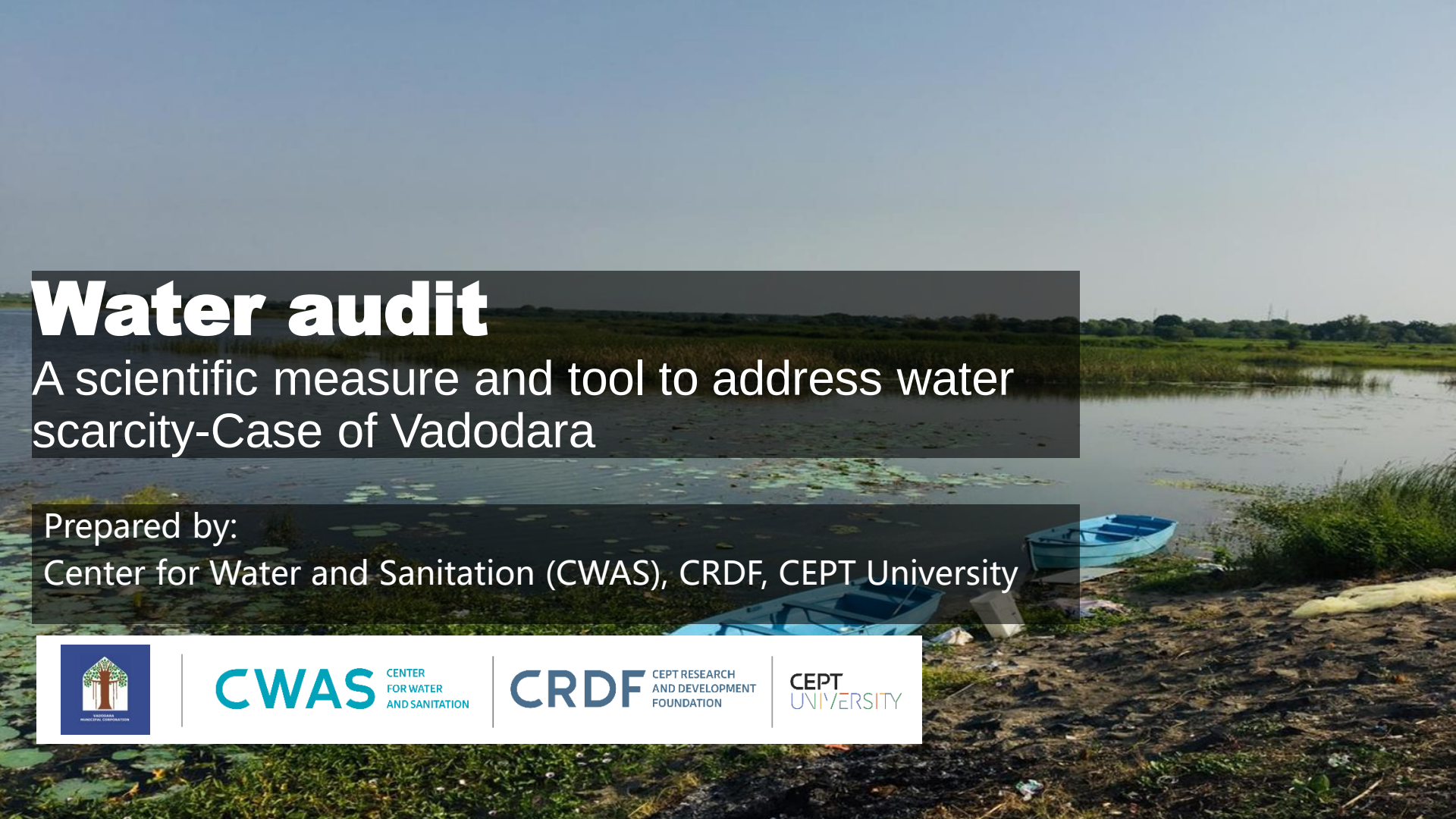


# Water audit

## A scientific measure and tool to address water scarcity-Case of Vadodara

Prepared by:
Center for Water and Sanitation (CWAS), CRDF, CEPT University

VADODARA MUNICIPAL CORPORATION

CWAS CENTER FOR WATER AND SANITATION

CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION

CEPT UNIVERSITY

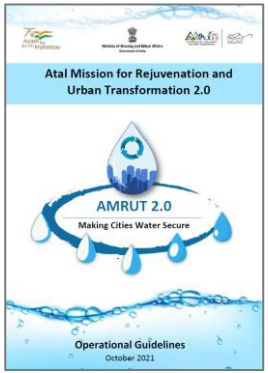
# Global and national focus on WATER

**The global annual water loss quantity is predicted to be 126-billion-meter cube, costing over 3900 crore dollars each year.**


UN-mandated Sustainable Development Goal (SDG) 6 aims to "**ensure availability and sustainable management of water and sanitation for all**"


**WATER** is at a central place in the climate talks at COP26

- **Water and Climate Pavilion at COP26**
- **Countries to integrate water and climate agendas at national level**




**City Water Balance Plans and City Water Action Plans** are one of the key components of AMRUT 2.0

# Vadodara City Profile

- Vadodara is an important industrial city, in Gujarat.
- The topography of the city is generally flat with a gentle slope from the North-East to South-West.
- The climate of the city is moderately dry and arid.
- Vadodara receives 900 mm rainfall annually.
- River Vishwamitri flows through the city, splitting it in half.
- Vadodara has been covered under the AMRUT program and Smart City Mission.

Total area of VMC - **159.95 Sq. Km.**

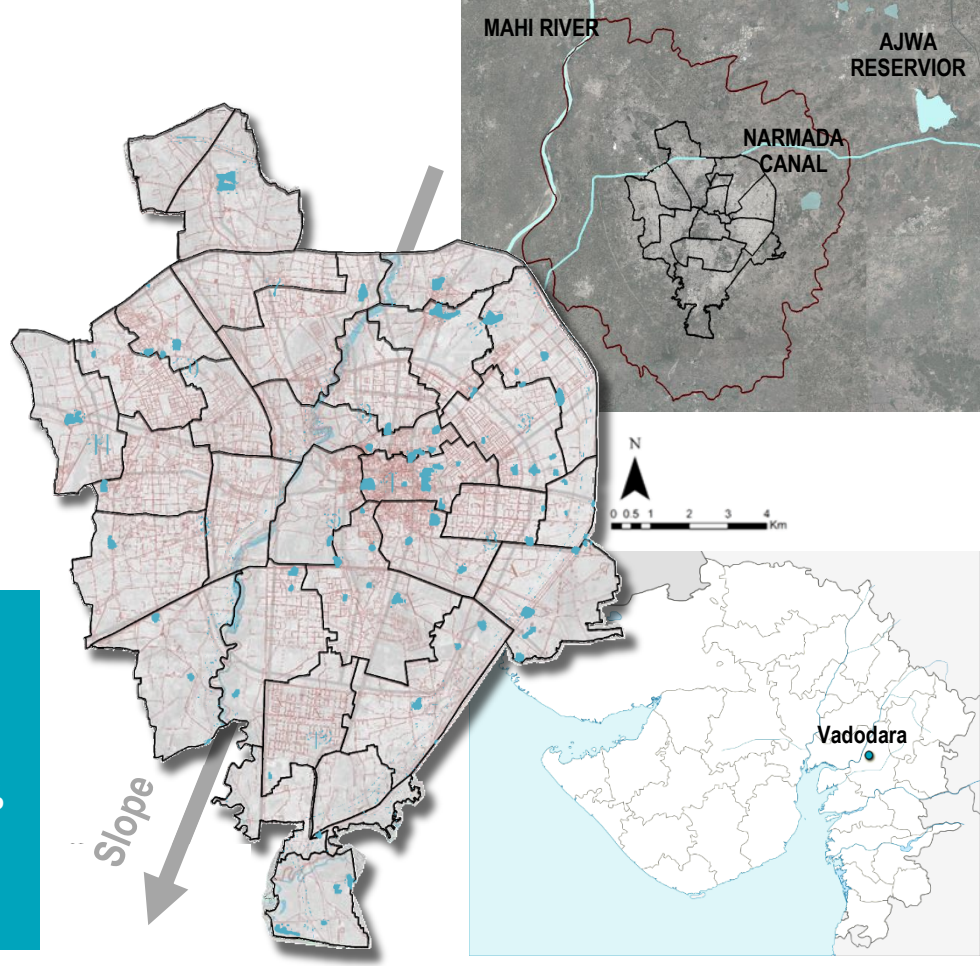
Current Population (2021) – **23.3 Lakhs**

Population (2011 Census) – **17.5 Lakhs**

Slum population (As per 2011 census and projected pop): **17.8%**

Growth rate per annum – **2%**

Total number of Households – **5.92 Lakhs**




Source: VMC, Census 2011

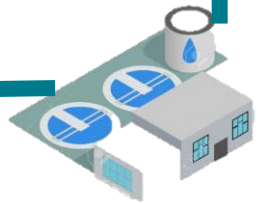
# VMC daily supplies 539 MLD water to the city

Source | Treatment | Distribution

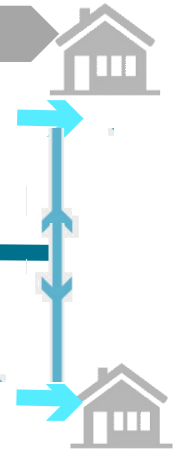
362 MLD estimated demand

**539 MLD**
Water supplied

Transmission line



Distribution line



**Mahi river: 243 MLD**

- Fajalpur: 80 MLD
- Poicha: 76 MLD
- Dodka: 20-25 MLD
- Raika: 62 MLD

**Ajwa : 144 MLD**

**Narmada canal: 67 MLD**

**Tube wells*: 38 MLD**

*66 tube-wells distributed around the city

Chlorination

Nimeta WTP

Khanpur WTP

**Water Zones: 4**

**Command Area: 31**

**ESR: 32**
**GSR: 55**
**Boosters:7**

**Total length of the network: 1,650 km**

**Total domestic consumption > Total domestic demand**

**Total no. of connections: 3.25 lakhs**

**Metered:~21,000**

**Individual water connections in slums: 31,740 (98%)**

**2% dependency on stand-posts for slums**

Source: Water works dept., VMC, DPR for Improvement of Water Supply Arrangement, VMC

# According to SLB, VMC has effective coverage for water supply, there is a need to assess demand management and NRW losses..

**99%**
Coverage of individual water supply connections in city
Benchmark: 100%
**Reliability: B**

**98%**
Coverage of individual water supply connections in slums
Benchmark: 100%
**Reliability: B**

**166 lpcd**
Per capita supply of water at consumer end
Benchmark:135 lpcd
**Reliability: C**

**27%**
Extent of Non-revenue water
Benchmark:20%
**Reliability: C**

**7%**
Extent of functional metering of water supply connections
Benchmark:100%
**Reliability: A**

**100%**
Quality of water supplied
Benchmark:100%
**Reliability: A**

**99%**
Efficiency in redressal of customer complaints
Benchmark:80%
**Reliability: A**

**78%**
Cost recovery in water supply services
Benchmark:100%
**Reliability: A**

**90%**
Collection efficiency of water taxes & charges
Benchmark:90%
**Reliability: A**

**1 hr/ day**
Continuity of water supply
Benchmark:24 hrs/day
**Reliability: A**

Source: PAS SLB Data 2019-20

Improvement measures required

# Good performance of VMC in terms of SLB… city received complaints of water quality and inadequacy of water supply

**Consumers**

- Inspite of **good SLBs**, major news coverage about inadequacy and Vadodara Municipal Corporation received complaints from the consumers for **inadequate water supply** and poor **water quality.**

**VMC**

- VMC argues that these are **false complaints**.
- The **Corporation claims adequate water** supply to the consumers--- VMC assumes there is **overconsumption of water** at consumer end.

Municipal Corporation ▸ Municipal Corporation of Vadodara

## Vadodara Municipal Corporation — drinking water supply

om Vadodara, Gujarat

Quality of drinking water supply has been approved by vmc since last few years. But there is insufficient quantity of water received at home. Water is distributed only for 1 hour, & at low pressure; it is not sufficient. This low pressure may be due to leakges in pipe or unlegally operated water-pumps to take extra water.
Kind request to corporation to solve this issue on urgent basis. As either it will help to save water in case of pipe leakges or it will help to needy people in case of water-pump case.

Printed from
THE TIMES OF INDIA

## Water woes rise for societies in Makarpura

TNN | Mar 28, 2018, 04.17 AM IST

VADODARA: Amid rising temperatures, residents of several societies located behind the Makarpura state transport bus depot and Makarpura Airforce Station have been left high and dry by the Vadodara Municipal Corporation (VMC). The societies are not getting sufficient water and, in many cases, citizens are forced to go to the nearby public taps for filling drinking water.
Residents claim that for nearly three years now, the water pressure has gone down significantly and motors have to be used to suck water from the pipelines. Even this yields insufficient water and many rely on bore wells to take care of their needs. At times, they even depend on tankers for water supply in these areas.

# CWAS initiated assessment of water supply system

- **Mapping of existing processes** and systems of water supply management of VMC.
- **Excellent initiative of digital governance: SCADA implementation, GIS mapping of database, Smart Water Portal**
- VMC water works department **doesn't utilize SCADA readings** to **monitor water levels** or assess leakages
- Reporting of water levels and other parameters is still done **manually in registers.**
- **Challenges of unintegrated database**
- **Metering of 21,000+ water connections** at HH level through 24*7 water supply projects under JnNURM and Smart City
- **Challenges of no water meter policy – normal tariffs are charged, doesn't fulfill the purpose of metering**

**Excellent initiative by VMC to introduce digital governance**


**Unintegrated database.**



Source: Based on discussions with VMC officials, 2021

# Actions taken by VMC to manage and reduce losses in the system

## Authorized Unbilled

**341** ✔

Public stand-posts in the city, less dependency due to 98% coverage of individual water connections

**50** ✔

- Parks and gardens
- ESRs/Pumping Stations
- VMC Office, ward offices

**12-15 MLD**

supplied to nearby villages

**Dodka RCW -** supplies to village 2 hrs/day through 2-inch connections, unaccountable

**Nimeta WTP-** 12-13 MLD supplied to villages , no accountability of water

## Un-Authorised Unbilled

**486** Illegal connections identified by VMC in the city ✔

**45 MLD** Water lost

- **Action Taken by VMC:** In 2018, VMC took an active step by legalizing the connections and prepared a policy to fix this.
- However, this issue can be tackled by regular monitoring.

Illegal connection in Akotanagar

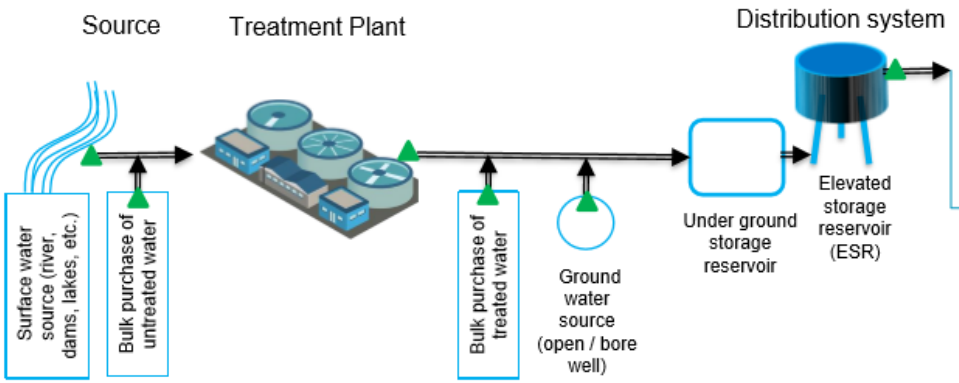
## Real Losses

**Losses in transmission network ?**

**Losses in distribution network ?**

**27%**
Extent of Non-revenue water
Benchmark:20%

# 18% real losses found from source to distribution stations based on SCADA readings against SLB of 27%




**Transmission Network**

- **18% real losses calculated** in the transmission network from source to all the ESRs and GSRs through SCADA data provided by VMC.

| Source | Water Supply (in MLD) |
|---|---|
| Khanpur WTP | 75.4 |
| Fajalpur RCW | 69.2 |
| Raika RCW | 70.6 |
| Raika Tube well | 10.0 |
| Dodka RCW | 28.7 |
| Dodka WTP | 50.0 |
| Poicha RCW | 80.7 |
| Nimeta WTP | 153.0 |
| Total water from source (in MLD) | 537.5 |
| Sum of total water at ESRs / GSRs and Booster sump (in MLD) | **440.8** |
| NRW losses in distribution channel (in MLD) | **96.7** |
| NRW losses in distribution channel (in %) | **18%** |

| | LocationTypeName | LocationName | Sensor_Desc | MLD | LogDate | Colum |
|---|---|---|---|---|---|---|
| 2 | Source | Fajalpur RCW | FAJ_FTE01 | 33.931 | 6/20/2021 | |
| 3 | Source | Fajalpur RCW | FAJ_FTE02 | 35.256 | 6/20/2021 | |
| 4 | Source | Raika RCW | RAI_FTE03 | 32.036 | 6/20/2021 | |
| 5 | Source | Raika RCW | RAI_FTE04 | 38.515 | 6/20/2021 | |
| 6 | Source | Dodka RCW | DOD_FTE05 | 13.488 | 6/20/2021 | |
| 7 | Source | Dodka RCW | DOD_FTE06 | 15.222 | 6/20/2021 | |
| 8 | Source | Poicha RCW | POI_FTE08 | 41.047 | 6/20/2021 | |
| 9 | Source | Poicha RCW | POI_FTE09 | 39.648 | 6/20/2021 | |
| 10 | Source | Sherkhi Intake Well | SHR_FTE10 | 88.115 | 6/20/2021 | |
| 11 | Source | Nimeta 1 WTP | | NA | 6/20/2021 | |
| 12 | Source | Nimeta 2 WTP | | NA | 6/20/2021 | |
| 13 | Source | Nimeta 3 WTP | | NA | 6/20/2021 | |
| 14 | Source | Khanpur WTP | KHW_FT047 | 75.36 | 6/20/2021 | |
| 15 | Source | Dodka WTP | | NA | 6/20/2021 | 50 |
| 16 | Junction | Soma Talav Junction | STJ_FT058 | 23.502 | 6/20/2021 | |
| 17 | Junction | Soma Talav Junction | STJ_FT059 | 42.426 | 6/20/2021 | |
| 18 | Junction | Airport Circle Junction | ANG_FT061 | 47.64 | 6/20/2021 | |
| 19 | Junction | Sardar Estate Junction | SDR_FT51 | 11.067 | 6/20/2021 | |
| 20 | Junction | Sardar Estate Junction | SDR_FT52 | 11.109 | 6/20/2021 | |
| 21 | Junction | Sardar Estate Junction | SDR_FT53 | 29.107 | 6/20/2021 | |
| 22 | Junction | Sardar Estate Junction | SDR_FT54 | 46.82 | 6/20/2021 | |
| 23 | Junction | Sardar Estate Junction | SDR_FT55 | 27.475 | 6/20/2021 | |
| 24 | Junction | Sardar Estate Junction | SDR_FT56 | 94.984 | 6/20/2021 | |
| 25 | Junction | Mahavir Hall Junction | MVR_FT57 | 13.981 | 6/20/2021 | |
| 26 | Junction | Dumad Junction | SAJ_FT62 | 136.951 | 6/20/2021 | |
| 27 | Junction | Opp Bright School | ANG_FT060 | 36.854 | 6/20/2021 | |
| 28 | Junction | Polytechnic Junction | POLY_FT64 | 1.082 | 6/20/2021 | |
| 29 | Junction | Bapu Ni Dargah | BND_FT65 | 73.35 | 6/20/2021 | |

Daily Reading_June 20th | NRW Analysis

Daily readings of flow meters for the month of June installed at the ESRs

**97 MLD losses in transmission network**

**Means only 9% losses from OHTs to HHs---?**

Source: CWAS Analysis based on real-time data shared by VMC, 2021

# Preliminary water audit as a scientific tool that provides rationale for assessment of water losses in the system…

**Oct 2021**

**Project Initiation**
VMC facing **water issues** – VMC approaches CEPT – Losses identified through SCADA readings

**Nov – Dec 2021**

**Selection of pilot area:**
**Karelibaug OHT** selected for pilot – Consultant to conduct water audit appointed

**Jan 2022**

**Audit of OHT :**
**Analysis of SCADA** readings – on campus inspection of water and energy losses

**Feb 2022**

**Bucket Survey:**
**250 consumer samples** for **bucket survey** – based on random sampling method in which all typologies covered

**March 2022**

**Identifying Network losses:**
Junction valves inspection - measurement of water flow with ultrasonic flow meters

**April 2022**

**Completion of water audit:**
**Assessment of losses** - key observations - recommendations

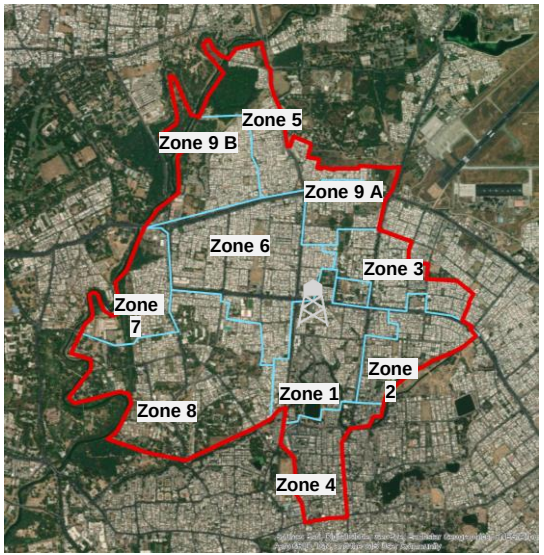
# Overview of Karelibaug command area

- **Command Area: 1.8 MLD overhead water tank** serves around 28,000 properties.
- **Source and Inlet:** Water is daily supplied from Mahisagar French well and is measured through a bulk flow meter.
- **Additional Water Supply in Command Area:** Feeder lines from Raika & Dodka run through VIP road to suffice the demand gap.
- **Storage:** Water is stored in **3 underground sumps** of **3.5 MLD each** along with the OHT.
- **70%** low rise buildings are found in the area due to proximity to airport.
- **Slum pockets:** There are **4 slum pockets** in the command area – Jalaram nagar, Tulsivadi, Malli mohallo and Panjari mohallo.
- **Water Supply sub-zones :** There are total **9 water supply** sub-zones - **4 morning water supply zones and 5 evening water supply zones.**
- **Water Quality: Chlorine** dozing is monitored at regular interval and quantity is checked to maintain the supply standards.
- **Record Keeping:** Water supplied is calculated manually based on water levels and pumping duration.

Karelibaug OHT
Capacity: 1.8 MLD

70% low rise buildings

Tulsivadi Slum




Karelibaug OHT Command Area (6.6 sq. km)

Flow meter at OHT

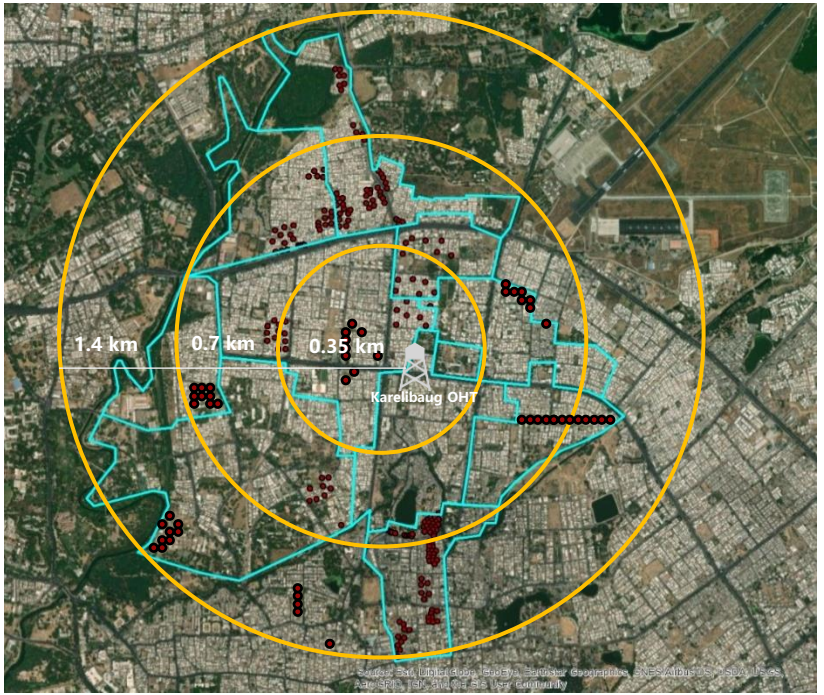
Source: Based on site visits and survey of Karelibaug OHT and command area, 2021

# Bucket survey at consumer end to assess water consumption

- Total **28,770 water connections** registered in the tax base.
- **No documentation of water connections** OHT/ sub zone-wise. Number of water connections in each sub-zone was analysed and mapped using weighted average method using GIS mapping tool.
- **250 samples** were considered based on **random sampling method** with 90% confidence level.
- **Bucket survey** was carried out in **9 sub-zones ( slum HH, non-slum HH and commercial)** of Karelibaug command area during the water supply hours at head and tail of network.
- **Buckets of 15 litres and 20 litres** were used to record volume of water using a stopwatch.

Bucket Survey at consumer end.

20 litres of bucket used for survey




Karelibaug command area boundary

Bucket Survey Samples

Source: VMC; CWAS analysis based on desk research, January 2022

# Water audit at Karelibaug OHT reported losses and leakages

- **Flow meter readings** from SCADA were recorded
- **Hourly based readings** were taken from the tank to measure water level. This was done by filling the tank full.
- **Leakages in valves** were observed and detected at the OHT
- **Total 11% losses (2.63 MLD)** were calculated on an average basis based on the readings.

## Water audit at the OHT

Survey to capture hourly based readings at OHT

Leakages at the OHT

**Loss at OHT water level**

| Sr.No | Date | Time | Water level | Water Loss (liter) | Remark |
|---|---|---|---|---|---|
| 1 | 17th Jan, 22 | 12 | 13 | 1560000 | Day |
| 2 | | 9 | 11 | 1320000 | Night |
| 3 | 18th Jan, 22 | 12 | 12 | 1440000 | Day |
| 4 | | 8 | 10 | 1200000 | Night |
| 5 | 19th Jan, 22 | 12 | 12 | 1440000 | Day |
| 6 | | 8 | 13 | 1560000 | Night |
| 7 | 20th Jan, 22 | 12 | 12.9 | 1548000 | Day |
| 8 | | 8 | 10 | 1200000 | Night |
| 9 | 21st Jan, 22 | 12 | 13 | 1560000 | Day |
| 10 | | 8 | 9 | 1080000 | Night |
| 11 | 22nd Jan, 22 | 12 | 13 | 1560000 | Day |
| 12 | | 8 | 11.3 | 1356000 | Night |
| 13 | 23rd Jan, 22 | 12 | 8 | 960000 | Day |
| 14 | | 8 | 5.6 | 672000 | Night |
| 15 | Total | | | 18456000 | |
| 16 | Average of 7 Days | | | 2636571.5 | |
| 17 | Leakage MLD | | | 0.11 | |
| 18 | **% Leakage Loss** | | | **11%** | |

Hourly based readings from flow meter at OHT for seven day

Source: Primary Survey, January 2022

# Losses in valves and pipelines

## Losses in valves

- **103 valves** with size of 20 inches, 16 inches, 12 inches, 10 inches, 8 inches, 6 inches, 4 inches.
- Measurement was taken at various points by taking out the water from the leakage valve with DG set pump (primer) and stopwatch methodology

Leakages in valves in the Karelibaug command area

## Losses in pipelines

- During morning and evening the operation by the operator at different locations has been observed. It is observed that there are water leakages due to opening and closing of the valves by the operators.
- **Replacement of valves and pipelines** is done based on requirement. VMC spends **50 lakhs per annum** for the contract of repair and replacement of valves and pipelines. .
- Total losses identified in the valves and pipelines are **0.2 MLD**

Water losses in pipelines

Source: Based on water audit by Soham Tech and CWAS team at the Karelibaug OHT, January 2022

# Inequitable water supply in slum and non-slum HHs

**Avg. Water supplied per Connection**

**451**
**Litres / Connection / Day**

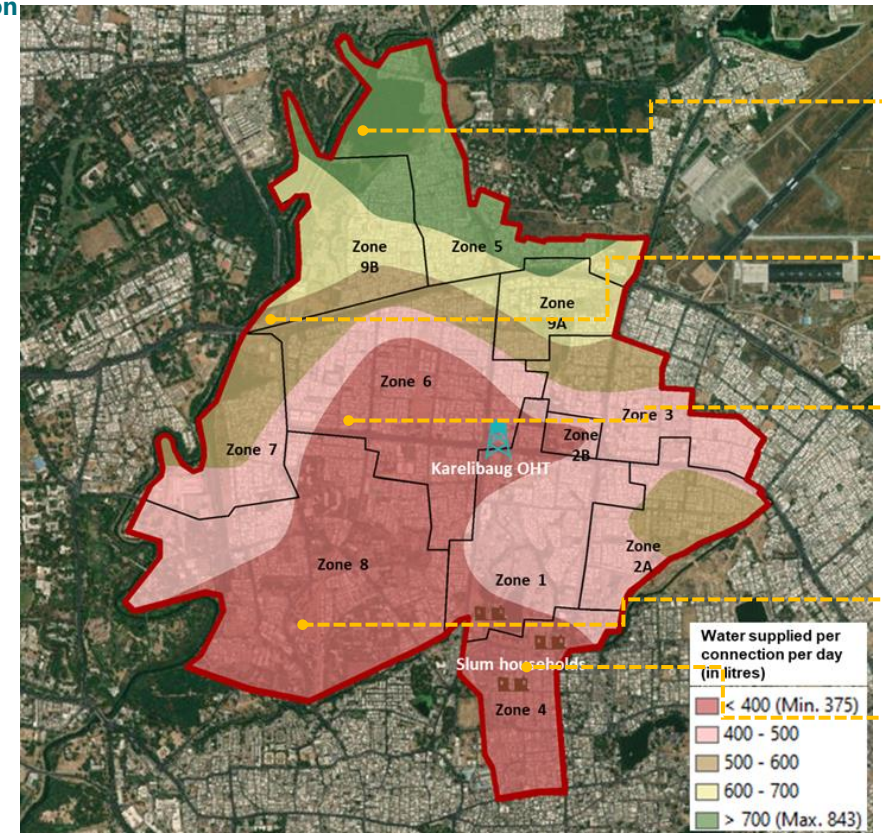
HHs with **slum** observes lower per capita water supply

**609**
**Litres / Connection / Day**

Wide variation in water supply in **non slum HHs** is noted from survey

**851**
**Litres / Connection / Day**

Large sized pipe diameters commercial zones receive higher per capita water supply




**Inequity in water received at consumer ends**

**Inequity** in water supply hours leading to **over consumption** of water in some zones.

Achieve per capita as per standards due to **direct feeder line connections** in the area

Issues related to poor **water pressures** in areas with topographical differences.

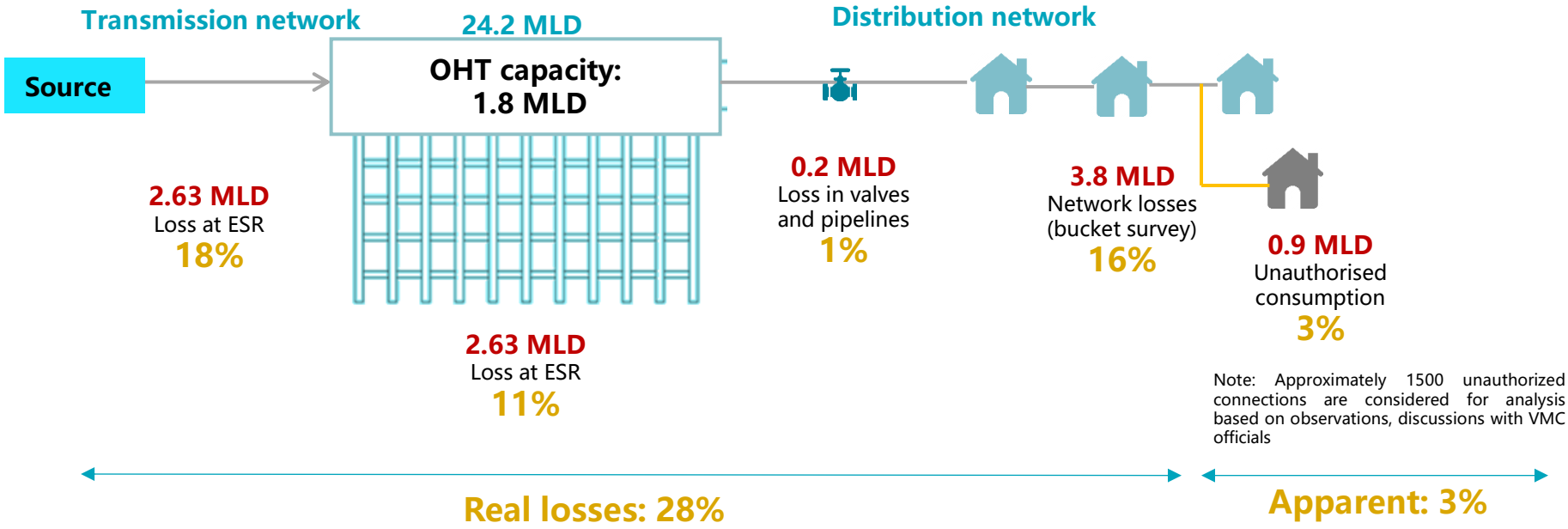
**Unaccounted water** supply from Warasia booster pump in few areas.

**Water theft** observed in slum pockets of Hathikhana due to low water pressure.

Source: CWAS, CEPT analysis based on results from water audit

# Total water losses in Karelibaug OHT, valves, pipes and network is found to be 31%

**Total NRW Loss from Source to Households for Karelibaug Command Area**



# Non-revenue water comes at a cost!!!

**IWA Chart for Karelibaug OHT**

| | | | | |
|---|---|---|---|---|
| System Input Volume **24.2 MLD** | Authorized Consumption (16.7 MLD) **69%** | Billed Authorized Consumption (16.7 MLD) **69%** | Billed metered consumption (NA) | **Revenue Water** (16.7 MLD) **69%** |
| | | | Billed unmetered consumption (16.7 MLD) **69%** | |
| | | Billed Unauthorized Consumption (0.02 MLD) **0.05%** | Unbilled metered consumption (NA) | |
| | | | Unbilled unmetered consumption (0.02 MLD) **0.05%** | |
| | Water Losses (7.5 MLD) **31%** | Apparent Losses (0.9 MLD) **3%** | Unauthorized consumption (0.9 MLD) **3%** | **Non Revenue Water (7.5 MLD) 31%** |
| | | | Metering inaccuracies (NA) | |
| | | Real Losses (6.6 MLD) **28%** | Leakages in transmission mains (3.8 MLD) **16%** | |
| | | | Leakages and overflow at storage tanks (2.63 MLD) **11%** | |
| | | | Leakage distribution and on service connections up to the measurement point (0.2 MLD) **1%** | |

- The total losses found in the Karelibaug water-supply system from **source to households** is **11.85 MLD**.
- The cost of the water losses is estimated to be **23 lakhs per month** which is beared by VMC.

**Total NRW Loss per day: 11.85 MLD**

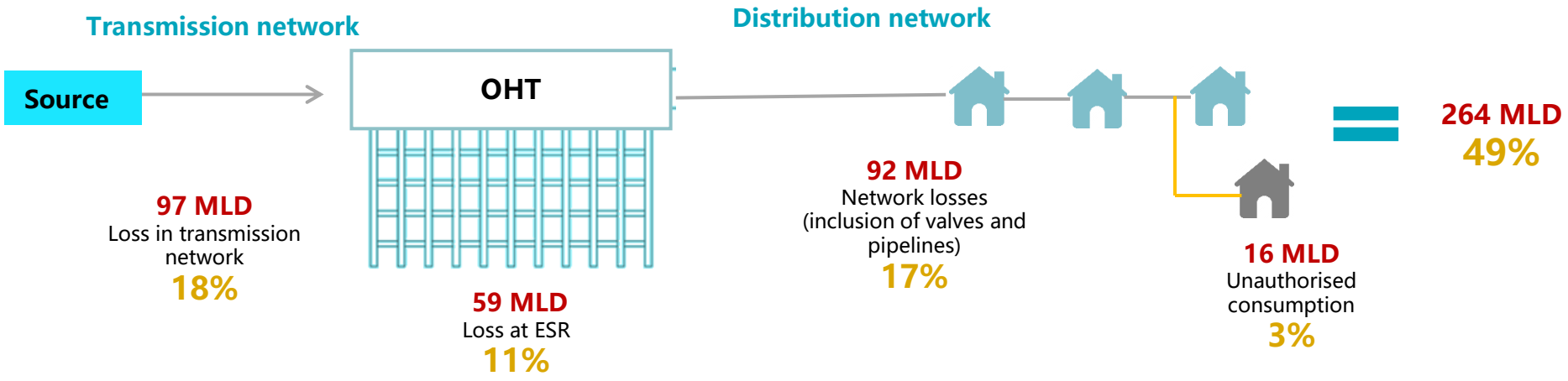
**Cost of 1 MLD for VMC: Rs. 6,470**

**Monetary loss of Rs. 23 Lakhs/ Month**

*Note: Calculations done based on 1 kl= Rs. 6.4 provided by VMC, 2022*

# Total water losses in the city in the system will cost 62 crore to VMC!!!

**Total NRW Loss from Source to Households for Karelibaug Command Area**




| | |
|---|---|
| **Total NRW Loss per day:** | **264 MLD** |
| **Cost of 1 MLD for VMC from source to HH:** | **Rs. 6,470** |

**Monetary loss of Rs. 62 crore/ annum for VMC**

# Recommendation: Water loss reduction strategy and capacity building plan for VMC

Based on the Water Audit results, few recommendations need to be incorporated by VMC to further prepare a strategy to scale the NRW reduction strategy model at city level.

- **Repair leakages** at the OHT, valves and distribution lines.

- **Performance based contract linked with reduction of water losses** for maintenance of distribution network

- **Capacity building of VMC waterworks department** for utilization of SCADA data.
- **Training sessions and workshops** to address NRW losses.

- **Regularisation** of unauthorised connections.
- Structured **equivalent** water supply timings

- **Awareness campaigns for consumers** regarding **water conservation**

Way Forward: Meeting with VMC commissioner and officials

# Thank you

C-WAS CENTER FOR WATER AND SANITATION
CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION
CEPT UNIVERSITY

https://cwas.org.in

## About us

The Center for Water and Sanitation (C-WAS) at CEPT University carries out various activities – action research, training, advocacy to enable state and local governments to improve delivery of services.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