Challenges in Transforming Intermittent Water Supply to 24x7 Continuous Supply - A Case Study of the Aurangabad City

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MD Dahasahasra Waternet Solutions

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Professor Visvesvaraya National Institute of Technology, Nagpur
Why No 24x7 Water Supply in India?

Prerequisites for 24x7 Supply

India (Intermittent Supply)

Developed Countries (24x7 Supply)
India - Missing Pre-Requisites

- Tanks operations (emptying)
- GIS Maps
- Operational Zones
- GIS Hydraulic Model
- DMA methodology
- NRW reduction
- Refurbishment of network
- Equitable distribution and pressures

Missing
Proper Engineering Study
Contents of Presentation

1. Overview of water supply in India
2. Difficulties and challenges of Urban Water Sector
3. Objectives
4. Challenges in Aurangabad
5. GIS Hydraulic model
6. Equitable distribution of water
7. O&M of 24x7 water supply
Difficulties of Urban Water

- **BEST PRACTICE**
- Replication missing
- Lacking
- Smart City
- No attempt for PPP
- Huge Arrears
- Inadequate
- **Loan**
- Customer Focus
- **AICE'17**
- Total Water Solutions
Challenges of Urban Water in India

- Utility Life > 29 years
- Meters (Negligible)
- Coverage 49%
- Supply Hours < 3
- NRW 50%

Source: HPEC GoI
Managing Burden on the Infrastructure

Challenges in Urban India

- High NRW
- Few Supply Hours
- Low LPCD
- No Meters
- Water Shortage

100 Cities in the list of smart cities

Smart Cities Mission

Aurangabad

Source: HPEC GoI
**Smart City - Definition**

What is smart city?

**Key ‘smart’ sectors**
- smart energy
- smart integration
- smart public services
- smart mobility
- smart buildings
- smart water

**Smart city** encompass six important sectors that need to work in unison to achieve a common goal of making a city more **livable, sustainable and efficient** for its residents.

Source: www.waterworld.com
Objectives

System of 24/7 water supply for Aurangabad City

- Water supply round the clock to all areas of the city;
- Equitable flow and pressure;
- Technology of 24/7 water supply suitable to India;
- Reduction of non-revenue water;
- Refurbishment and expansion of transmission and distribution network.
Objectives

• Discusses use of advanced technologies of GIS
• Simulation of pipe network system using WaterGEMS
• Suggest the modifications required to rebuild the system
  - Scenario Management
  - Boundary of operational zones
  - Active Topology tool- to create boundary of DMA
  - Darwin Designer for optimization of pipe network;
  - Darwin Calibrator
  - Identify the probable leaking pipes
  - Criticality tool- locations of isolating valves
  - Step Tests required for determining NRW in DMAs.
Aurangabad City

- Admin. HQ of Marathwada,
- Tourism Capital of Maharashtra,
- Fastest growing city,
- Population - 1.2 Million (2011)
Challenges of the Existing Water Supply of Aurangabad

- **Bulk Water**
  - Shortage of Water: 50 LPCD
  - Losses = 22%
  - Old Pumping Machinery: 1974 and 1991
Challenges of the Existing Water Supply of Aurangabad

- Uneven Terrain:
- Level difference, in the range of 525 m to 840 m
Old GI and Non-metallic pipes

AC Pipe

There is a water loss

Joints of AC pipes loosen
Aurangabad: Old AC Pipes

Length (Kms) of Existing Pipelines

<table>
<thead>
<tr>
<th>Material</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>561</td>
</tr>
<tr>
<td>CI</td>
<td>259</td>
</tr>
<tr>
<td>RCC</td>
<td>8</td>
</tr>
<tr>
<td>MS</td>
<td>37</td>
</tr>
<tr>
<td>GI</td>
<td>3</td>
</tr>
</tbody>
</table>

Legend:
- AC: 255, 0, 0
- CI: 0, 128, 0
- DI: 0, 0, 255
- GI: 0, 255, 255
- HDPE: 255, 128, 0
- MS: 138, 13...
- PVC: 238, 130...
- RCC: 255, 165, 0
Tampering of Pipelines

1. Water collection during supply
2. PVC pipes have been punctured
3. Water is collected in pits
4. Pumps are used to suck water
5. Outside dirt enters in PVC pipeline
6. People suffer a lot due to low pressure
Aurangabad: High NRW

<table>
<thead>
<tr>
<th>Location</th>
<th>NRW (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head work</td>
<td>10.96</td>
</tr>
<tr>
<td>MBR</td>
<td>7.04</td>
</tr>
<tr>
<td>ESR</td>
<td>39.67</td>
</tr>
<tr>
<td>Total</td>
<td>58%</td>
</tr>
</tbody>
</table>
Contamination due to Intermittent Supply

Challenges in Distribution System

How Disease Spreads?

When empty, pipeline creates a back siphoning effect that sucks in contaminants.
Challenges in Distribution System

Intermittent Supply Hours

Common Man Says..
We Build-Neglect and Rebuild

Water with low Pressure

45 Minutes once in 2 days
Challenges in Distribution System

Large Number of Valves

- No. of valves = 2646
- No. of valve men = 123
Challenges in Distribution System

Large Number of Valves

Civic Employees Are Extorting Money From Citizens By Choking Their Water Supply

A BEND IN THE SYSTEM

The city draws 3,470 million litres of water a day from six lakes.

Before being provided to the public, the water is flown into two major treatment plants using a portion of the city's 4,000 km-long pipeline network.

It is then directed to 24 major reservoirs located across the city.

From there, it is distributed equally among 113 zones at different hours.

Who Are Chabiwallas:
Civic employees, their job is to open the valves on smaller pipelines at different hours of the day to regulate water supply across the city.

Arm-Twisting:
As in a tap, the pressure of water one gets depends on how much these valves are turned. Chabiwallas lower the water pressure and, at times, shut the supply to societies on purpose.

Money Flow:
In return for correcting the water supply, chabiwallas extort money from societies and building residents.

Chabiwallas have been known to extort money from residents of big slums and chawls, particularly in the eastern suburbs, during festive seasons. The attendant crisis is, many a time, diffused by the local corporator after claiming his or her share of the pie.

For chabiwallas, hotels, industries and call centres are a major source of money. They regularly increase the water pressure to these establishments and, at least on one occasion, have diverted the water meant for other areas by modifying the network.

Bribes help turn water taps on
Challenges in Distribution System

Improper Operation Zones

Tanks Remain Empty or Overflowing

Getting Empty

Overflowing

Not Desirable

Store water in non-peak hours and release in peak hours

How engineers manage?
## Status of Water Supply

- **Coverage, Water Supply Connections**
- **Per capita supply of water**
- **Extent of metering**
- **NRW Reduction**
- **Continuity of water supply**
- **Quality of water Supply**
- **Redressal of complaints**
- **Cost recovery in water supply services**
- **Efficiency in collection of water charges**

### 9 Performance Indicators (GoI)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Standard</th>
<th>India</th>
<th>Maharashtra</th>
<th>Aurangabad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage</td>
<td>100%</td>
<td>49%</td>
<td>48.03%</td>
<td>85%</td>
</tr>
<tr>
<td>Per capita supply</td>
<td>135 LPCD</td>
<td>132 LPCD</td>
<td>75 LPCD</td>
<td>61</td>
</tr>
<tr>
<td>Water supply</td>
<td>100%</td>
<td>Negligible</td>
<td>14.9</td>
<td>0%</td>
</tr>
<tr>
<td>Extent of metering</td>
<td>20%</td>
<td>50%</td>
<td>37%</td>
<td>58%</td>
</tr>
<tr>
<td>NRW Reduction</td>
<td>24 Hours</td>
<td>3 Hours</td>
<td>1.7 Hours</td>
<td>Once in 3 days- 45 minutes</td>
</tr>
<tr>
<td>Redressal of complaints</td>
<td>100%</td>
<td>NA</td>
<td>95.17%</td>
<td>95%</td>
</tr>
<tr>
<td>Continuity of water supply</td>
<td>80%</td>
<td>NA</td>
<td>93.63%</td>
<td>30%</td>
</tr>
<tr>
<td>Cost recovery in water</td>
<td>100%</td>
<td>30-35%</td>
<td>54.46%</td>
<td>27%</td>
</tr>
<tr>
<td>Efficiency in collection</td>
<td>90%</td>
<td>NA</td>
<td>38.06%</td>
<td>67%</td>
</tr>
</tbody>
</table>

Solutions Proposed

How We proceeded?

Converting to 24x7 Water Supply System?
The Strategies

5 Important Measures

Technical

GIS

Hyd. Model

DMA

Metering

O&M to Sustain 24x7

Volumetric Pricing

Management Contracts

Adequate

Illegal Connections

Rehabilitation of network

Pressure Management

Leakage Management

Bulk + Consumer

Reduction of NRW

24x7 Water Supply

Present W.S.

Organization

Commercial

Policy

Budget

Important Measures

The Strategies

5 Important Measures

Technical

GIS

Hyd. Model

DMA

Metering

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Reduction of NRW

24x7 Water Supply

Present W.S.

Organization

Commercial

Policy

Budget
Implementation Steps

Design Stage
- Intermittent Supply System
  - Base Drawing
  - Prepare Hydraulic Model
  - Scenario of zones and DMAs

Construction and O&M Stage
- Install meters and PRVs
- Water Audit
- Tackle leakiest DMA
- Leak repair, Rehabilitate pipes

Basic principle
- Save water by plugging leaks.
- The saved water is then used to increase the supply hours.

All DMAs tackled?
- Y
  - 24x7 Continuous Supply System
- N
  - Tackle all DMAs
How can we overcome challenges of our current Water Supply Systems?

Answer is..

- GIS based Hydraulic Model
- NRW reduction
- 24x7 Continuous water supply

Drawings required
Map Creation

GIS

GIS
Hydraulic
Model

Bentley
WaterGEMS

We Created Background Map
Satellite Image of a city

Digital Globe Satellite:
- Pan sharpened
- 0.5 m Resolution

GIS

AICE'17
TOTAL WATER SOLUTIONS
10-11 November, 2017 | The Lalit, Mumbai
Aurangabad - Road Map

24/7 Water Supply

- NRW Reduction
- Replacing Consumer Pipe
- Pipe Rehabilitation
- Leakage Control
- Water Audit
- DMA Creation
- Operation Zone Creation
- GIS Based Hydraulic Model

Reforms - Not Possible - Without GIS Based Hydraulic Model
GIS Based Hydraulic Model

Definition

Network Modelling → Actual water supply system using Computer software

process of creating a representation

Source: Haestead methods- advanced water distribution modelling and management
Hazen-William Equation:

\[ h_f = kQ^{1.852} \]

\[ k = \frac{10.68L}{C^{1.852}D^{4.87}} \]

Node | Continuity Equations
--- | ---
1 | \[ q_1 = Q_1 + Q_4 \]
2 | \[ Q_1 = q_2 + Q_2 \] (Linear: No Exponent)
3 | \[ Q_2 + Q_3 = q_3 \]
4 | \[ Q_4 = q_4 + Q_3 \]

Pipe | Energy Equations
--- | ---
1 | \[ h_{f1} = (H_1 - H_2) = k_1Q_1^{1.85} \] (Non-Linear: Exponent)
2 | \[ h_{f2} = (H_2 - H_3) = k_2Q_2^{1.85} \]
3 | \[ h_{f3} = (H_4 - H_3) = k_3Q_3^{1.85} \]
4 |
### Continuity Equations

<table>
<thead>
<tr>
<th>Node</th>
<th>Equations</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>( q_1 = Q_1 + Q_4 )</td>
</tr>
<tr>
<td>2</td>
<td>( Q_1 = q_2 + Q_2 )</td>
</tr>
<tr>
<td>3</td>
<td>( Q_2 + Q_3 = q_3 )</td>
</tr>
<tr>
<td>4</td>
<td>( Q_4 = q_4 + Q_3 )</td>
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</table>

### Energy Equations

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( h_{f1} = (H_1 - H_2) = k_1 Q_1^{1.85} )</td>
</tr>
<tr>
<td>2</td>
<td>( h_{f2} = (H_2 - H_3) = k_2 Q_2^{1.85} )</td>
</tr>
<tr>
<td>3</td>
<td>( h_{f3} = (H_4 - H_3) = k_3 Q_3^{1.85} )</td>
</tr>
<tr>
<td>4</td>
<td>( h_{f4} = (H_1 - H_4) = k_4 Q_4^{1.85} )</td>
</tr>
</tbody>
</table>

**Linear:**
- No Exponent

**Non-Linear:**
- Exponent

**Non-Solution:**
- Non-Linear Equations
What happens inside Hydraulic Model?

Solution

q₁ = Q₁ + Q₄

h_f₁ = (H₁ - H₂) = k₁Q₁^{1.8}

Convergence Methods

Linear

Scientist

Non-Linear

Hardy-Cross Method

Global Gradient Method

Linear Theory Method

Newton-Raphson Method

Non-Linear Solution

Scientists

Linear

Convergence Methods
How we created GIS based Hydraulic Model of Aurangabad City?
Remodelling of Aurangabad Distribution Pipe Network
Remodeling of Aurangabad Distribution Pipe Network

Use existing pipe network?

Or

Construct a new pipe network?
Remodeling of Aurangabad Distribution Pipe Network

Construct a new pipe network?

Use existing pipe network?

Rationale

- Discard old and leaking AC, PVC pipes
- Existing pipes with exact maps and database are used
- For 100% coverage new pipes are designed

We had to discard 80% existing pipes

We thought:

Discard old and leaking AC, PVC pipes
Existing pipes with exact maps and database are used
For 100% coverage new pipes are designed

We had to discard 80% existing pipes
## Discarding Old and leaking Non-metallic Pipes

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Diameter (mm)</th>
<th>Material</th>
<th>Length (km)</th>
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<tbody>
<tr>
<td>1</td>
<td>80 to 400</td>
<td>AC</td>
<td>561</td>
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<tr>
<td>2</td>
<td>80 to 750</td>
<td>CI</td>
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<td>3</td>
<td>80 to 450</td>
<td>RCC</td>
<td>53</td>
</tr>
<tr>
<td>4</td>
<td>200 to 1400</td>
<td>MS</td>
<td>47</td>
</tr>
<tr>
<td>5</td>
<td>50 to 100</td>
<td>GI</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>150 to 600</td>
<td>DI</td>
<td>37</td>
</tr>
<tr>
<td>7</td>
<td>63 to 250</td>
<td>PVC</td>
<td>3</td>
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</table>

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Existing (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CI</td>
</tr>
<tr>
<td>100</td>
<td>5.7</td>
</tr>
<tr>
<td>150</td>
<td>24.8</td>
</tr>
<tr>
<td>200</td>
<td>12.0</td>
</tr>
<tr>
<td>250</td>
<td>4.6</td>
</tr>
<tr>
<td>300</td>
<td>5.1</td>
</tr>
<tr>
<td>350</td>
<td>0.9</td>
</tr>
<tr>
<td>400</td>
<td>0.1</td>
</tr>
<tr>
<td>450</td>
<td>0.0</td>
</tr>
<tr>
<td>500</td>
<td>0.7</td>
</tr>
<tr>
<td>600</td>
<td>0.0</td>
</tr>
<tr>
<td>Grand Total</td>
<td>54</td>
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</tbody>
</table>

Before

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Existing (Km)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>CI</td>
</tr>
<tr>
<td>100</td>
<td>5.7</td>
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<tr>
<td>150</td>
<td>24.8</td>
</tr>
<tr>
<td>200</td>
<td>12.0</td>
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<td>250</td>
<td>4.6</td>
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<td>500</td>
<td>0.7</td>
</tr>
<tr>
<td>600</td>
<td>0.0</td>
</tr>
<tr>
<td>Grand Total</td>
<td>54</td>
</tr>
</tbody>
</table>

After

**Discarded**

Grand Total

967

AICE’17
TOTAL WATER SOLUTIONS
10-11 November, 2017 | The Lalit, Mumbai
Model of Existing and New Pipelines

Create shape files of roads, buildings, WTP, tanks, water bodies etc.

Identify places where pipelines are not supposed to be laid.

Show new pipes for 100% coverage.

Creation of GIS Based Hydraulic Model.
3D Stereo Paired Satellite Image of Aurangabad city

- Elevations to Nodes
- Demand to nodes
- Prepare operational zones

We purchased this image for Aurangabad
TREX: Assigns Level to Nodes

GIS

Hydraulic Model

Bentley WaterGEMS
Aurangabad: Growth by Land Use Pattern

Population Density
Roads
Buildings
Elevation
Land Usage
Real World

Legend:
- High
- Low
- Medium
- Saturated
- Very High
Load Builder: Demand to Nodes

GIS

GIS P.D. Layer

GIS Hydraulic Model

Load Builder

Bentley WaterGEMS

Theissen Polygon
Aurangabad: Area Served by Existing Tanks

- Pipes served by existing tanks
- Pipes unserved by any tanks
Creating Operational Zones of Aurangabad using GIS based Hydraulic Model
What is Operational Zone?
Determining Boundary of a Operational Zone

Tentatively fix boundary of zone for ESR

Find the demand of nodes which fall within this boundary

Using this demand compute tank capacity using mass curve method

Is tank getting empty?

Y

Modify boundary of the zone

Lower demand or pumping hours

N

Increase demand or modify pumping hours

Is tank getting overflow?

Y

Modified boundary is correct

N
Scenarios in Aurangabad

Existing: 26
New: 45
Total Scenarios: 71

One scenario per operational zone
DMA Creation in Aurangabad

How Active Topology of WaterGEMS helped?
What is DMA?

- DMA inlet
- District Meter
- DMA Boundary
- Hydraulically discrete
- Closed Valves painted in red
- Pipe Network
- Customer’s House
- Customer’s Meter

\[ Q_{nrw} = Q_{in} - Q_c \]

500 to 3000 Customers
DMA Creation in Aurangabad

Active Topology - Creating DMAs

- Inactive pipes - grey colour,
- Active pipes - 4 colours,
- Only active elements are evaluated
- DMAs Pd_1, Pd_2, Pd_3 and Pd_4 are marked,

Pundalik Nagar DMAs
Steady State Method

Present Demand

Future Demand

Is Velocity \( \leq 1.8 \text{ m/s} \) and Pressure \( \geq 17 \text{ m} \)

N

Y

Sizes Adequate

Modify Size of pipe

Modify Size of pipe
What is Darwin Designer?

Darwin Designer ➔ Genetic Algorithm ➔ Optimise Pipe Network

Darwin’s Principle of Evolution

Fittest to survive

Homo habilis 2.8 million years ago

Homo heidelbergensis 50,000 to 100,000 years ago

Homo sapiens 50,000 years ago
Design using GIS based Hydraulic Model

What happens inside Darwin Designer?

Objective Function: Minimise cost

Constraints

Pool of Solutions - A.. B.. C

Checks for Fitness

Set of optimal solutions

Crossover

Mutation

A

100 100 150

B

100 200 200

100 200 200

100 150 200
Equitable Flow and Pressure

Exclusive inlet to each DMA

- Ensures equal pressure and flow to all DMAs
- Pundlik Nagar OZ for design

A tank supplying water to different DMAs by separate inlets
Tank Level Management

Inflow = Outflow

$Q_{in} = Q_{out}$

FCV-1
FCV-2
Tank Level Management
Using FCV

Getting Empty
Inflow < Outflow

Overflowing
Inflow > Outflow

Inflow = Outflow
Inflow = Outflow

- Float on top: FCV closes flow
- Float at bottom: FCV opens flow
How FCV Works?

- Weight of water $<$ Spring force
  - Opens the gap
  - Increases Flow and pressure

- Weight of water $>$ Spring force
  - Throttles the gap
  - Reduces Flow and pressure
O&M Planning

NRW Reduction for Converting to 24x7 Water Supply System?

Tools Used:

- Criticality
- Darwin Calibrator
Optimise Number of Isolation Valves

Use of Criticality

Objectives:
- Place isolation valves optimally
- Segmentation
- Preparation of STEP test

Aurangabad - Pundalik Nagar
“Criticality” – A Tool for Step Test of NRW Reduction Strategy

Total 24 sections are formed

<table>
<thead>
<tr>
<th>SN</th>
<th>Section</th>
<th>Controlling ISO valves</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S1</td>
<td>1, 3, 4, 18, 19, 20</td>
</tr>
<tr>
<td>2</td>
<td>S2</td>
<td>2, 3, 4, 5, 18, 20, 24</td>
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<td>3</td>
<td>S3</td>
<td>15, 21, 24, 32</td>
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<td>4</td>
<td>S4</td>
<td>7, 13, 14, 15, 25, 31, 32</td>
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<td>5</td>
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<td>6</td>
<td>S6</td>
<td>5, 33, 34</td>
</tr>
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<td>7</td>
<td>S7</td>
<td>16, 17, 26, 34</td>
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<td>8</td>
<td>S8</td>
<td>6, 16, 17, 22, 26</td>
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<td>S9</td>
<td>22, 27, 28</td>
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<td>10</td>
<td>S10</td>
<td>6, 27, 28, 37</td>
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<tr>
<td>11</td>
<td>S11</td>
<td>8, 9, 30, 36</td>
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<td>S12</td>
<td>9, 10, 11, 12, 30</td>
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<td>S13</td>
<td>2, 9, 10, 11, 12, 30</td>
</tr>
<tr>
<td>14</td>
<td>S14</td>
<td>2, 8, 10, 11, 12, 13, 31, 35</td>
</tr>
</tbody>
</table>

Aurangabad- “Pundalik Nagar”
Step Test - To Compute NRW

- Systematic closure of section valves
- Measure flow at entry point of DMA
- Open valves in reverse way
- Again measure flow

Inflow is known

Measure consumer’s consumption at mid-night

NRW = Supply - Consumption
Aurangabad

Leakages Through House Service Connections

- Fenceline/boundary
- Isolation valve
- Meter
- Backflow prevention device
- Main cock
- Council’s service pipe
- Council’s water main
- Garden tap
- To house

HOUSE PLUMBING

300mm
NRW - Definition

NRW = \frac{\text{Water put into distribution system - Total water billed}}{\text{Water put into distribution system}} \times 100

NRW is a good indicator for water utility performance

**High levels**
- Poorly managed water utility
- Detrimental to financial viability
- Quality of water

“Lost” before it reaches the customer
Our Goal

We must attempt to reduce NRW

Source: (1) MOUD, June 2012
(2) Journal of Mechanical and Civil Engineering, 2013
(3) AMRUT PPT
## NRW: Components

<table>
<thead>
<tr>
<th>System Input</th>
<th>Authorized Consumption (m³/Yr)</th>
<th>Billed Authorized Consumption</th>
<th>Billed Metered Consumption</th>
<th>Billed Unmetered Consumption</th>
<th>Revenue Water (m³/Yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Volume</td>
<td>Authorised Consumption (m³/Yr)</td>
<td>Unbilled Authorized Consumption</td>
<td>Unbilled Metered Consumption</td>
<td>Unbilled Unmetered Consumption</td>
<td>Non Revenue Water (m³/Yr)</td>
</tr>
<tr>
<td>Volume</td>
<td>Water Losses (m³/Yr)</td>
<td>Apparent Losses</td>
<td>Unauthorised Consumption</td>
<td>Customer Meter Inaccuracies</td>
<td>Revenue Water (m³/Yr)</td>
</tr>
<tr>
<td></td>
<td>Real Losses</td>
<td>Real Losses</td>
<td>Leakage on Transmission and Distribution Mains</td>
<td>Leakage and Overflows at Storage Tanks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Leakage on Service Connections up to point of Customer Meter</td>
<td></td>
</tr>
</tbody>
</table>

**Input** = **Q_{nrw}** + **Q_c**

Source: International Water Association (IWA)
Darwin Calibrator Helps to Locate Leaking Pipe
Leak Detection - A Cumbersome Job
### Darwin Calibrator Helps to Locate Leaking Pipe

<table>
<thead>
<tr>
<th>Time (hour)</th>
<th>Observed Inflows: PUP-12 (MLD)</th>
<th>Observed Pressures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PUJ-1 (m)</td>
</tr>
<tr>
<td>0</td>
<td>2.60</td>
<td>12</td>
</tr>
<tr>
<td>1</td>
<td>2.60</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>3.60</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>16.79</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>16.39</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>31.97</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>32.96</td>
<td>10.53</td>
</tr>
<tr>
<td>7</td>
<td>32.96</td>
<td>10.53</td>
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<tr>
<td>8</td>
<td>32.96</td>
<td>10.53</td>
</tr>
<tr>
<td>9</td>
<td>32.96</td>
<td>10.53</td>
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<tr>
<td>10</td>
<td>24.97</td>
<td>10.96</td>
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<tr>
<td>11</td>
<td>4.20</td>
<td>11.55</td>
</tr>
<tr>
<td>12</td>
<td>4.20</td>
<td>11.55</td>
</tr>
<tr>
<td>13</td>
<td>4.20</td>
<td>11.55</td>
</tr>
<tr>
<td>14</td>
<td>4.20</td>
<td>11.55</td>
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<tr>
<td>15</td>
<td>4.20</td>
<td>11.55</td>
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<tr>
<td>16</td>
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<tr>
<td>19</td>
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<td>10.53</td>
</tr>
<tr>
<td>20</td>
<td>32.96</td>
<td>10.53</td>
</tr>
</tbody>
</table>

*Flow Meter: Red triangle
Pressure Gauge: Green circle*
### Darwin Calibrator Helps to Locate Leaking Pipe

![Image of leaking nodes on a map]

<table>
<thead>
<tr>
<th>Node</th>
<th>Original Emitter Coefficient (L/s/(m H2O)^n)</th>
<th>Adjusted Emitter Coefficient (L/s/(m H2O)^n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUJ-437</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>PUJ-193</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>PUJ-58</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>PUJ-397</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>PUJ-249</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>PUJ-99</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>PUJ-237</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>PUJ-414</td>
<td>0</td>
<td>0.3</td>
</tr>
<tr>
<td>PUJ-405</td>
<td>0</td>
<td>0.3</td>
</tr>
<tr>
<td>PUJ-438</td>
<td>0</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Way Forward

DPR of PPP Project
Appoint Operator
Manage DMAs
Reduce NRW
24x7 Water Supply
Achievements in Water Sector

- **Jamshedpur** with 573,000 inhabitants provided 25% of its residents with continuous water supply in 2009.
- **Navi Mumbai**, with more than 1m inhabitants, has achieved continuous supply for about half its population as of January 2009.
- **Badlapur**, city in the Mumbai Metropolitan Area with a population of 140,000, had achieved continuous supply in 3 out of 10 operating zones, covering 30% of its population.
- **Thiruvananthapuram**, with a population of 745,000 in 2001, is probably the largest Indian city that enjoys continuous water supply.
- Recently, **Malkapur** town, Jalochi urban agglomeration in Maharashtra have achieved the hallmark of 100% continuous water supply.
- In **Amravati** city 1.36 Lakhs people are getting benefit of continuous water supply.
- It is heartening to mention here that the Malkapur and Amravati city administrations get National Urban Water Award for this outstanding work.
Conclusions

GIS Map -> GIS Hydraulic Model -> Enough No. of tanks and zones -> Rehabilitation of distribution pipes

Pressure Management -> Metering -> DMA -> Replacement of GI HSC by MDPE HSC

Reduction of NRW -> Sustainable Utility -> Improved service delivery -> 24x7
Awards in Advance Distribution Modeling

22 May 2006, “Disaster Management” BE Excellence Award 2006, at Charlotte, USA


21 Oct 2008, Best Engineer Award, at the hands of Hon. Governor, Maharashtra


11th Dec. 2009, Prestressed Concrete Award at Mangalore, Design and Research, I.E.
Thank You

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