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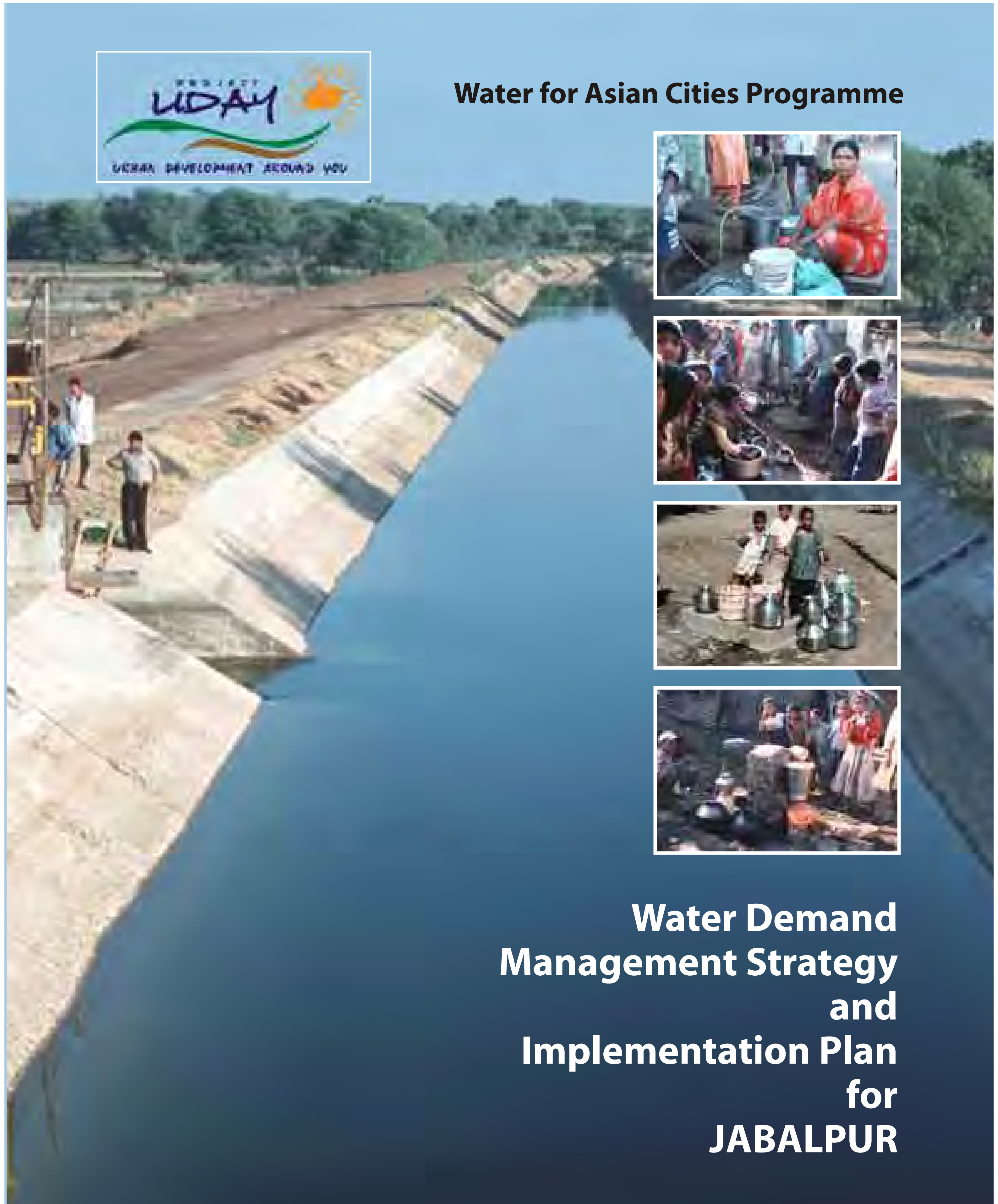

# Water Demand Management Strategy and Implementation Plan for JABALPUR


The Energy and Resources Institute

Water Resource Planning and Conservation

Government of Madhya Pradesh

ADB

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The Publication has been prepared under the overall guidance of Mr. Kalyan Ray, Senior Advisor, Office of the Executive Director, UN-HABITAT and close supervision of Mr. Andre Dzikus, Programme Manager, Water for Cities Programmes, Water, Sanitation and Infrastructure Branch of UN-HABITAT, Nairobi, with the support of Dr. Kulwant Singh and Mr. Aniruddhe Mukerjee of UN-HABITAT.

UN-HABITAT owes a great deal to The Energy Resources Institute (TERI) in commissioning this project in partnership with Water Resources Planning and Conservation (WRP), South Africa, who provided the water balance software for undertaking water balance study. UN-HABITAT would like to acknowledge the contribution of the Municipal Corporation of Jabalpur, the Public Health Engineering Department and other concerned organisations for their innovative inputs into the study.

# Message

**Jayant Kumar Malaiya**
Minister
Urban Administration & Development
Housing & Environment
Government of Madhya Pradash

UN-HABITAT under the Water for Asian Cities Programme in India is working in Bhopal, Gwalior, Indore and Jabalpur in support of the ADB financed Urban Water Supply and Environmental Improvement Project of Government of Madhya Paradesh for the improvement and expansion of urban water supply, sewerage and sanitation, water drainage and solid waste management in these cities. All four cities, have substantial population presently living in slums having difficulties in accessing both water and sanitation facilities.

UN-HABITAT has undertaken the Water Balance study in the four cities which revealed that the Non-Revenue Water (NRW) is between 33 and 60% in Bhopal, Gwalior, Jabalpur and Indore. The reduction of NRW can lead to availability of surplus water for the population in the slums, which are presently not having sufficient access to piped water supply.

I am pleased to learn that UN-HABITAT has developed a strategy and action plan on Water Demand Management (WDM) jointly with Urban Water Supply and Environmental Improvement (UWSEI) Project, Madhya Pradesh which proposes technical, financial and institutional measures to reduce NRW.

I hope that the implementation of the strategy and action plan will help the local bodies in improving the water supply condition of the four project cities and attainment of the Millennium Development Goals.

**Jayant Kumar Malaiya**

# Preface

Jabalpur is the third largest city in the State of Madhya Pradesh. The city is blessed with perennial water source and good rainfall and yet the water availability is unsatisfactory. Jabalpur supplies around 130 mld of treated water to an estimated population of around 1.2 million, besides utilisation 20 mld of ground water through tube wells and hand pumps. The actual situation is much less with estimated per capita availability of around 80 lpcd. Further, the city gets only 2 to 3 hours of water supply in a day with little reliability.

Assessment of the city water supply system highlights non-availability of most of the information on operational aspects. Absence of data on leakages and the reliability of the available basic data on the availability of water supply has been the major concern in arriving at water balance audit. Non-revenue water in Jabalpur city is estimated between 37 per cent to 43 per cent. The water supply problem in the city of Jabalpur is attributed more to the lack of infrastructure and current management practices rather than lack of water availability.

UN-HABITAT in partnership with Water Resource Planning and Conservation (WRP), South Africa and The Energy and Resources Institute (TERI), India commissioned the project on Water Demand Management and Implementation Plan for the cities of Bhopal, Gwalior, Jabalpur and Indor in the state of Madhya Pradesh, consequent to the Workshop on Pro-Poor Urban Water and Sanitation Governance held in March 2005 in Bhopal to bring together the primary and secondary stakeholders on the approach and strategies to be adopted in the implementation of the Water for Asian Cities Programme.

The Water Demand Management Strategy and Implementation Plan for the city of Jabalpur has been prepared by TERI based on the techniques and methodology provided by the WRP, South Africa.

The Publication presents a comprehensive reforms package by developing Water Demand Management Strategy and Implementation Plan for the city of Jabalpur involving institutional, financial and technical issues and is aimed at the efficiency improvements in management and utilization of water. The focus is mainly on the water balancing systems, developing information-base on GIS platform, capacity building and approaches for reducing unaccounted-for water, for an efficient and effective distribution of available water supply. The strategies and the implementation framework illustrated in the publication would not only enhance awareness but also provide the basis for formulating effective Water Demand Management policies.

**Andre Dzikus**
Programme Manager
Water for Cities Programmes
UN-HABITAT

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**Note:**

Rs. 1 crore: Rs. 10 million

Rs. 1 million: Rs. 10 lakhs

Rs. 10 lakhs: Rs. 1,00,000

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# Abbreviations

| | |
|---|---|
| APFC | Active Power Factor Conversion |
| ARV | Air Release Valves |
| ADB | Asian Development Bank |
| BWSSB | Bangalore Water Supply and Sewerage Board |
| BHEL | Bharat Heavy Electricals Limited |
| BMC | Bhopal Municipal Corporation |
| BPT | Break Pressure Tank |
| CI | Cast Iron |
| CGWB | Central Ground Water Board |
| CIB | Central Investigation Bureau |
| CWRPS | Central Water and Power Research Station |
| CMWSSB | Chennai Metropolitan Water Supply and Sewerage |
| CAGR | Compounded Annual Growth Rate |
| CII | Confederation of Indian Industry |
| CPI | Consumer Price Index |
| DMA | District Metered Areas |
| FCRI | Fluid Control Research Institute |
| GI | Galvanised Iron |
| GIS | Geographical Information System |
| GPS | Global Positioning System |
| GSR | Ground Service Reservoirs |
| HRS | Habibganj Railway Station |
| IIM | Indian Institute of Management |
| ILI | Infrastructure Leakage Index |
| IDEMI | Institute for Design of Electrical Measuring Instruments |
| IWA | International Water Association |
| KUIDFC | Karnataka Urban Infrastructure Development Finance |
| MAPCOST | Madhya Pradesh Council for Science and Technology |
| MES | Military Engineering Services |
| MDG | Millennium Development Goals and Targets |
| ML | Million Litres |
| MCJ | Municipal Corporation of Jabalpur |
| NMC | Nagpur Municipal Corporation |
| NRV | Non-Revenue Valve |
| NRW | Non-Revenue Water |
| OHT | Over Head Tanks |
| PSC | Pre Stressed Concrete |
| PHED | Public Health and Engineering Department |
| RPA | Receipt and Payment Account |
| RRL | Regional Research Laboratories |
| SGSITS | Shri G.S Institute of Technology of Science |
| SBI | State Bank of India |
| SEB | State Electricity Boards |
| TCE | Tata Consulting Engineers |
| ULB | Urban Local Bodies |
| VMC | Vishakhapatnam Municipal Corporation |
| WDM | Water Demand Management |
| WAC | Water for Asian Cities |
| WRP | Water Resource Planning and Conservation |
| WTP | Water Treatment Plant |

# Executive Summary

UN-HABITAT commissioned a study on Water Demand Management (WDM) in four cities of Madhya Pradesh to The Energy and Resources Institute (TERI), New Delhi, India and Water Resource Planning and Conservation (WRP), South Africa. The study is funded under the Water for Asian Cities (WAC) Programme, which is a collaborative initiative between the UN-HABITAT, the Asian Development Bank (ADB) and Governments of Asia. The scope of the assignment involved conducting a water balancing study, preparing a detailed database on a GIS platform and making recommendations for reducing unaccounted-for water so that available water supply is efficiently and effectively distributed. Aimed at the efficiency improvements in management and utilisation of water, the study looked at the cities of Bhopal, Gwalior, Jabalpur and Indore. The present study aims at developing a comprehensive reform package for Jabalpur involving institutional, financial and technical issues in water supply.

Current water supply to the Jabalpur city is mainly through three water sources: Narmada River, Khandari Dam-Gaur River System and Pariyat Dam-Fagua Nallah system. In addition, the supply is also augmented through groundwater sources though deep bore tube wells and hand pumps installed by the municipal corporation. Jabalpur supplies about 130 MLD of treated water to an estimated population of about 12.3 lakhs, besides it also withdraws 20 MLD of groundwater through tube wells and hand pumps.

Assessment of the city's water supply system highlights that most of the information on operational aspects is either unavailable or is available as a crude estimate. Absence of most of the data on leakages and reliability of the basic data has been a major concern in the calculations on water balance audit. The audit is therefore based on the best information available, which tends to be a mixture of assumptions that shall need formal vetting by the officials of Municipal Corporation in due course. Water Balance analysis based on the available information suggests that Non-Revenue Water (NRW) in Jabalpur city is estimated to be between 37% and 43%. This current water supply problem can therefore be attributed more to the lack of infrastructure and current management practices rather than lack of water availability. Water demand management is thus an approach, which can be used to improve the efficiency of the current system.

### WDM strategy

The first step to WDM is essentially to measure the water flowing in the system. It is practically impossible to implement any demand management strategy without metering. It is proposed that bulk meters should be installed at all inlet and outlet of treatment plant. Bulk metering at inlet to Bhongadwar WTP from Khanduri Dam, should be undertaken only after the replacement of the existing pipelines from Khanduri dam. For the open channel that carries water from Pariyat to the Ranjhi treatment plant, it is proposed that V-Notches or Level Gauges should be installed to monitor the flow as well as to ensure efficient supply to treatment plant by comparing inflow and outflow. Bulk revenue meters should be installed for revenue realisation from bulk consumers like MES, Defence Vehicle factory, SAF Battalion, GCF (Gun Carriage factory), Engineering college, etc. as these consume around 13.8 MLD of the total water supplied and pay a high percentage of the total revenue realised.

In Jabalpur, though a large number of the domestic consumers which have meters installed, but most of them are non-functional. The entire revenue is realized on a flat rate basis. The absence of metering coupled with an irrational tariff structure results in huge losses to the service provider, which leads to inadequate funds for proper O&M.

It is also suggested that energy audit should be carried out at all pump houses although at pilot phase, this should be carried out at pump house located at the outlet of Ranjhi WTP (Pump House 1) and Fagua pump house.

Leakages were prevalent at many locations in transmission and distribution lines. Heavy leakages were observed in the transmission line from Khandari Dam to Bhongadwar WTP. It is suggested that a dedicated team should be involved to carry out leak detection and repair. To begin with all visible leakages occurring from transmission pipes should be identified and repaired. It is also suggested that there should be phased replacement of tanker-based supply with small piped water networks in the areas supplied through tankers.

A pilot study area, Brahman Mohalla has been suggested for carrying out WDM Strategies such as District-metering areas (DMA), domestic consumer metering, water audit, identification of leakages and repair, preparation for GIS based database on extensive survey of pipelines, pressure management, carry out awareness campaign and regularising illegal connections. Such studies will help in assessing financial and technical inputs required to carry out implementation of these strategies at city level.

### Financial assessment

Currently, Municipal Corporation of Jabalpur (MCJ) follows a method of charging flat rates for domestic water supply, primarily because of non-functional metering at the consumer end. A flat tariff not only encourages indiscriminate and illegal water usage, but also acts as a disincentive for consumers to conserve water. The existing tariff structure needs to be rationalized to address cost recovery principles, improve collection efficiency and provide clarity to tariff design. An alternative to the current tariff structure is the 'two part' tariff structure. Such a tariff design typically includes a consumption/ volumetric rate in addition to the fixed water charge. It is also suggested to modify the prevalent municipal accounting and financial reporting systems from single-entry cash based to double-entry accrual based system. This system scores over the cash based accounting as it also takes into consideration credit transactions.

### Institutional reforms

As a first step to the reforms process, it is recommended that MCJ formulate a vision statement for provision of water supply services by involving all relevant stakeholders. This vision statement should draw upon the existing national and state water policies and urban development policies adopted by the state and national governments and also the expectations of the consumers. MCJ should also develop an Infrastructure Development Plan for provision of water supply services in Jabalpur, which will help in better management of water supply networks. Restructuring of the water works department is needed so as to very clearly demarcate all functions like planning, construction, design, distribution O&M and plant O&M. Creating special cells for functions such as leak detection, consumer grievances and database management should be undertaken. It is proposed that an awareness campaign should be carried out to regularise illegal connections in the areas like Madar Challa, etc for better revenue realisation. It is also suggested that MCJ should develop a comprehensive MIS that covers all aspects of water management and interlink with GIS, while also providing an opportunity to undertake performance measurement.

# 1 Introduction

Over the past decade sustainable access to water supply has emerged as one of the most critical development challenges facing the developing world. Scarcity of water resources coupled with inequitable distribution and inefficient use and distribution of water have led to a situation wherein a large percentage of the population in urban centres across the country have no access to safe drinking water and at the same time huge quantities of water is wasted through leakages and pilferages. Water Demand Management (WDM), which essentially encourages improvements in water distribution and use rather than augmentation of supplies has over the years emerged as an alternative approach to securing access to water supply for everyone on a sustainable basis.

In the above context, TERI in partnership with UN-HABITAT and Water Resource Planning and Conservation (WRP), South Africa, has undertaken a project to conduct a rapid assessment of the water supply services in Jabalpur and develop a water demand management strategy and implementation plan. The assignment also aims at building capacities for mainstreaming WDM principles in water supply planning at different organisational levels in Municipal Corporation of Jabalpur (MCJ).

The project is supported under the Water for Asian Cities (WAC) programme, a collaborative initiative between UN-HABITAT, ADB and the Government of Asia. The WAC programme supports capacity building, mobilizing political will, enhancing human resources, water education, and pro-poor investments in water and sanitation sector aimed at meeting the Millennium Development Goal (MDG).

## 1.1 Objectives

Objective of the project is to ensure long-term sustainability of water resources through interventions targeted at improving efficiencies in water distribution and use in urban water supply systems. The specific objectives of the project are:

1. Assessment of existing water supply operations including water balance apart from technical, financial and institutional issues;
2. Formulation of detailed WDM strategy and implementation plan for Bhopal, Gwalior and Jabalpur.
3. Capacity building at all levels in the four municipal corporations of Indore, Bhopal, Gwalior, and Jabalpur for developing WDM strategy and implementation plan for the cities.

## 1.2 Scope

As mentioned above, the project has three distinct components:

- **Current status assessment:** The scope of the study included a rapid assessment of the current water supply situation with specific reference to estimation of unaccounted-for water and preparation of water balance based on existing secondary datasets. In addition financial and institutional assessment of the municipal corporation was also undertaken which included identification of key issues and problems by a SWOT matrix analysis of institutional players and an analysis of the existing tariff structure including billing, pricing and recovery structure.

- **Strategy and implementation plan:** The findings from the assessment have been used to formulate a WDM strategy and implementation plan comprising of technical, financial and institutional strategies aimed at reducing UFW. In addition, pilot projects for immediate implementation have also been identified.

- **Preparation of GIS maps:** Existing water supply distribution maps available with the municipal corporation have been digitised and converted to a GIS platform for use as base maps for future expansion.

## 1.3 Approach and methodology

A WDM strategy essentially includes recommendations for improving the efficiencies in water use and distribution. Thus development of strategies for reducing NRW (Non Revenue Water) would require a thorough understanding of the water supply systems. In addition the root cause of inefficiencies in water supply systems are related more to the policy, institutional and financial challenges which get reflected in poor service delivery. Thus we had undertaken the study considering all the above issues.

Given the limited time and scope, the project was essentially based on the secondary data collected through visits to each of the city. The project focused on carrying out a water balance using data provided by/collected from the Municipal Corporation. Different rounds of data collection have been undertaken because of the poor quality of data and inadequacies in data. Further, limited flow monitoring was carried to fill in data gaps.

Based on the above investigations, different WDM strategies have been recommended, which include various aspects of technical, financial, and institutional changes required for better and more efficient delivery of water supply services.

Detailed methodology followed is given in Figure 1.1.

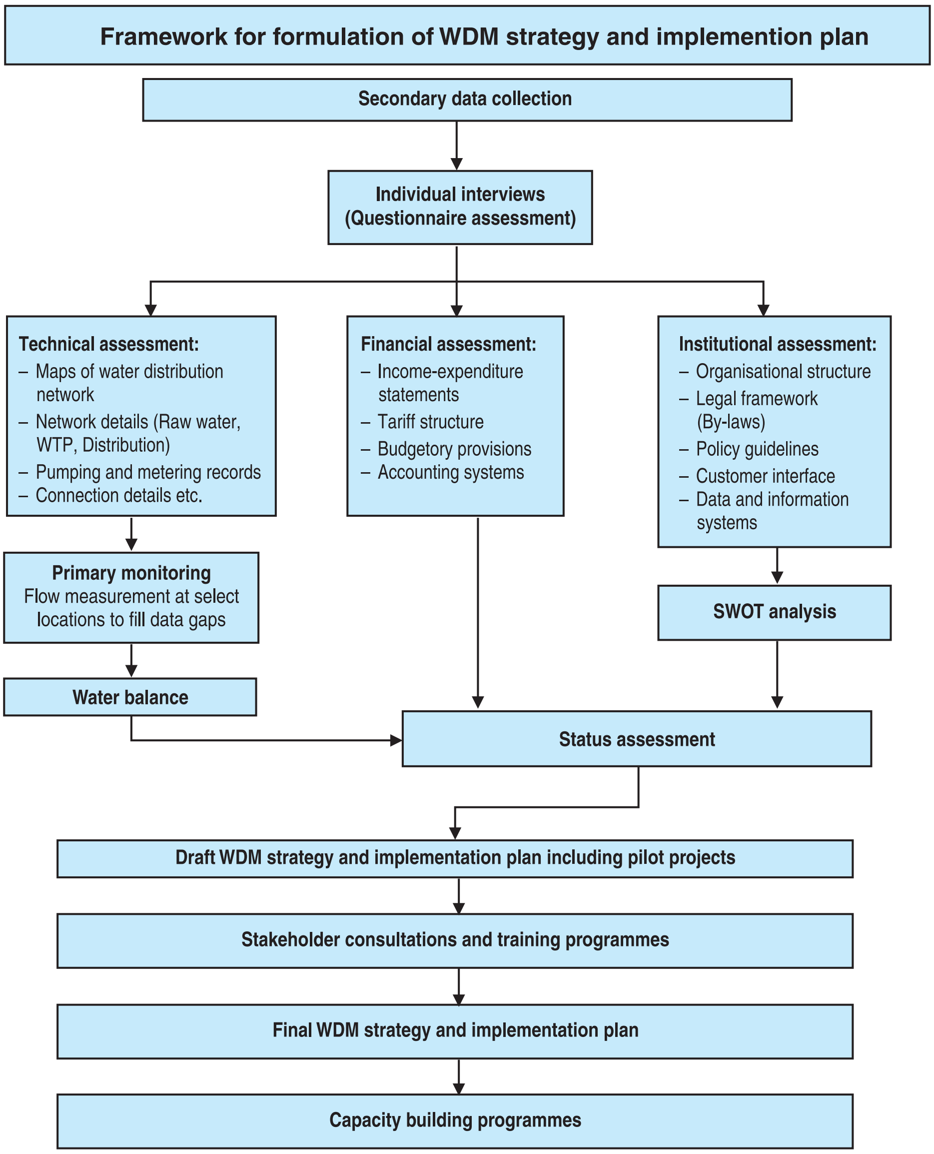



**Figure 1.1** Detailed methodology

## 1.4 Partners and Stakeholders in the study

As mentioned earlier, UN-HABITAT, TERI and WRP Consulting Engineers have jointly undertaken the WDM project. In addition SGS Institute of Technology and Science has been involved with the training and capacity building component of the study.

However, apart from the above, the following partners and stakeholders have also been involved in various stages of the study for providing data and feedback on the WDM reports as well as training.

1. Municipal Corporation of Jabalpur
2. Public Health Engineering Department
3. Bulk Consumers: MES (Military Engineering Services), GCF (Gun Carriage Factory), Vehicle factory, Ordinance factory and SAF Battalion
4. Project Management Unit (MP UWSEIP)
5. Project Implemention Unit, Jabalpur (MP UWSEIP)
6. Project Management Consultants and Design & Supervision Consultants for MP UWSEIP.

# 2 Status of Water Supply to Jabalpur City

Jabalpur city is situated on the banks of river Narmada at $23.10^0$ N latitude and $79.59^0$ E longitude. The city is situated in a low hill terrain with gradual slopes and large number of water bodies. The weather in Jabalpur is temperate with hot summers (April-June) and cool winters (November-February). It experiences southwestern monsoon rains in September with an annual average rainfall of around 1250 mm (47.3"). Figure 2.1 shows the location of Jablapur.

**Source:** www.mapsofindia.com


**Figure 2.1** Location map of Jabalpur

Jabalpur is the third largest city in Madhya Pradesh with a population of 950,000 (9.5 lakhs) as per the 2001 census. The city has a major defence establishment such as the Ordinance factory, Vehicles factory, MES. There is also a major cantonment within the city. The economic base of the city is mainly dominated by the public sector due the presence of larger number of government offices. Tourism and mining are the other prominent economic activities in the city.

Though the city has a perennial water source (Narmada) and good rainfall, the water availability in the city is unsatisfactory. The overall availability of water supply to Jabalpur from the sources is around 150 MLD (33 MGD), which translates into the per capita availability of 150 lpcd (33 MGD) considering no losses and equitable distribution. However in actual situation it is much less with estimated per capita availability of around 80 lpcd. Further most of the city gets only 2-3 hours of water supply in a day with little reliability. The problem can be attributed more to the lack of infrastructure and current management practices rather than lack of water availability to the town.

## 2.1 Water sources

Current water supply to the Jabalpur city is mainly through three water sources:

1. Narmada River
2. Khandari Dam-Gaur River System
3. Pariyat Dam-Fagua Nallah System

In addition, the supply is also augmented through groundwater sources though deep bore tube wells and hand pumps installed by the Municipal Corporation.

Table 2.1 summarises the volume of water supplied in Jabalpur from different sources.

**Table 2.1** Details of raw water sources and volumes supplied in Jabalpur

| Source supplied | Installed capacity MLD | Actual water |
|---|---|---|
| Pariyat Dam-Fagua Nallah | 54 (11.9) | 35 (7.7) |
| Narmada River | 97 (21.4) | 80 (17.6) |
| Khandari Dam-Gour River | 27 (6.5) | 23 (5) |
| Tubewells | 27 (6.5) | 20 (4.4) |
| Total | 205 (45.15) | 158 (34.8) |

### *2.1.1 Khandari Dam – Gaur River system*

#### *2.1.1.1 Raw water transmission*

The Khandari Dam – Gaur River system supplies raw water to the Bhongadwar Water Treatment Plant (WTP). Khandari Dam and Gaur River in combination supply about 27 MLD (6 MGD) of water to the Bhongadwar Treatment Plant. Khandari Dam is a rain-fed dam and is filled during the monsoon period and hence supplies water to city during non-monsoon period. The supply from Gaur supplements the supply from Khandari Dam however in the monsoon seasons water is drawn only from the Gaur River so that the Khandari Dam may be filled for use in the dry season.

Raw water to Bhongadwar WTP is supplied through a 6 km long gravity main of 610mm ϕ (24") gravity mains from Khandari and a 3 km long pumping main from Gaur. The pump house at Gaur has four pumps of 150 HP (two operating at a time) and two pumps of 120 HP (one operating at time).

Heavy losses were observed in the raw water transmission mains from Khandari to Bhongadwar. The pipeline was in dilapidated state and found to be leaking at several locations. A proposal to replace pipeline has been initiated by MCJ.

#### *2.1.1.2 Clear water transmission and distribution*

Bhongadwar treatment plant has a capacity of 27 MLD (6 MGD); it receives all its water from the Khandari Dam and Gaur River. The treatment system is based on clari-flocculation followed by sand filtration and disinfection. The loss in the treatment plant is estimated to be around 5-8%.

A schematic layout of the Khandari – Gaur system is given in Figure 2.2.

The treated water is collected in a sump of 4.5 ML (1 MG) capacity and supplied through gravity to the distribution network. Most of the supply is directly to consumers, the only tanks to which Bhongadwar suppies is Belbagh toriya and loko sump (each of 0.9 ML / 0.2 MG capacity respectively). The details of clear water transmission mains originating from Bhongadwar are given below:

- 762 mm (30") CI main supplies to Gorakhpur, Haubagh and Kantega for a duration of 5 hours in the morning as well as in the evening. This water gets mixed with water coming through 762 mm (30") diameter pipe from Lalpur treatment plant near Katinga crossing and then water is directly supplied to households or through OHTs.

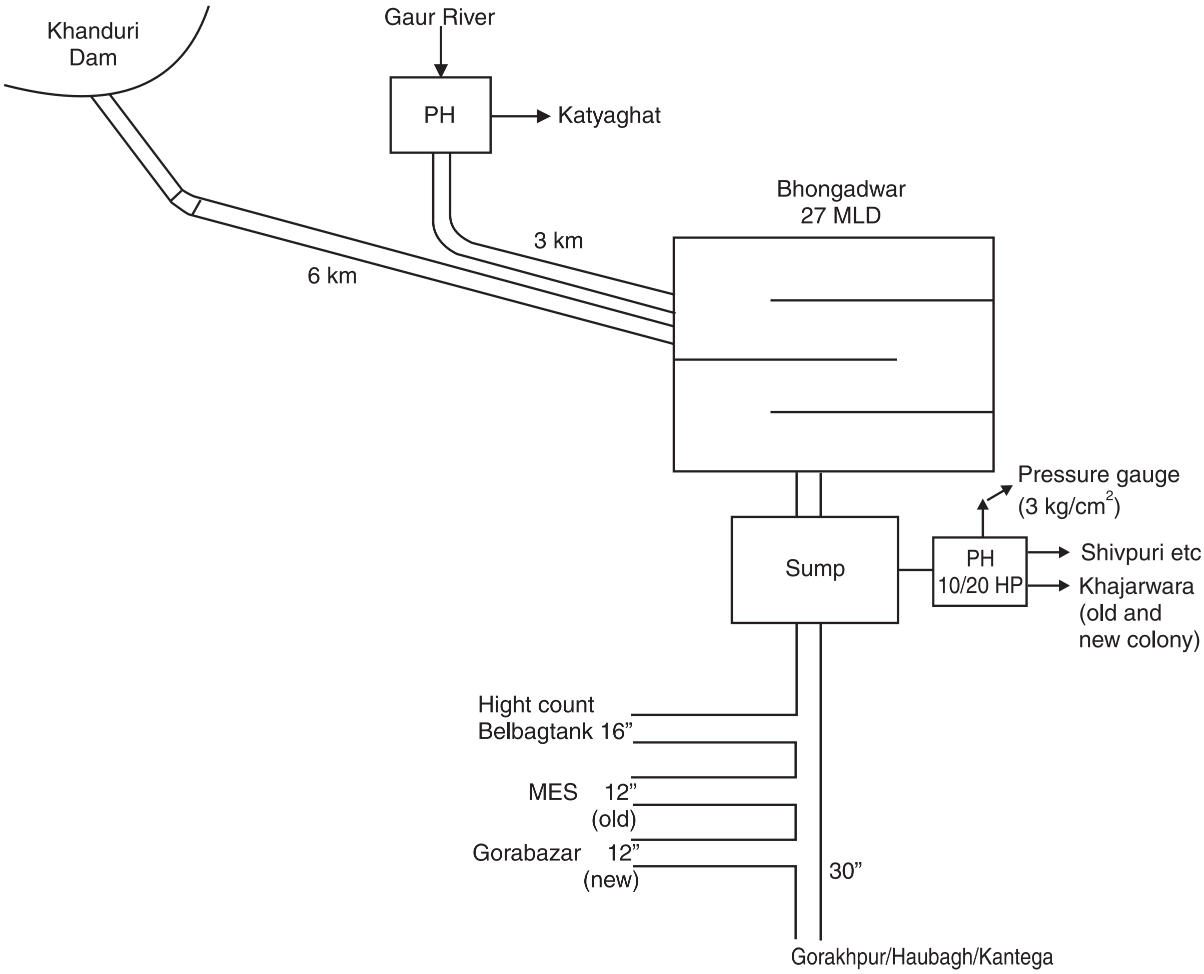



**Figure 2.2** Khandari – Gaur River System (Bhongadwar Treatment Plant)

- 406 mm (16" main) supplies to intermediate pumping station in High court area from where it is further pumped to the Belbagh Tank. This line is charged 24 hours and it directly serves few areas in addition to the Belbagh tank.
- A 305 mm (12") lines supplies to Civil lines and MES while another 305 mm (12") line supplies to the Gora bazaar area and the MES tank. Both these lines are also charged 24 hours. Water is supplied to civil line area to build pressure and then water from Narmada through civil lines OHT is supplied.
- A small pump house with a pumping capacity of 20 HP and 10 HP (one as standby) is also utilized for supplying water to Shivpuri through 101.6 mm (4") pipe, Kajarwara new colony through 101.6 mm (4") and to old colony through 152.6 (6") pipe. Water is supplied for three hours in the morning and three hours in the evening.

Water is supplied directly to 17 wards, out of which 5 wards receive water completely from Bhongadwar and remaining 12 wards receive water partly from Bhongadwar and partly from other treatment plants. Water from 762 mm (30") pipeline from Bhongadwar plant mixes with water from 762 mm (30") lalpur treatment plant near Katinga crossing in the city.

#### *2.1.2 Pariyat Dam and Fagua Nallah system*

#### *2.1.2.1 Raw water transmission*

The Pariyat reservoir is a rain-fed dam with a capacity of 18,500 Ml (4075 MG). It is estimated to supply 41 MLD (9 MGD) of water to the city through the Ranjhi water treatment plant. Water from the Pariyat Dam seepage (Fagua Nallah) is pumped to Ranjhi WTP while direct supplies from the dam reservoir is through gravity. In addition, about 11-13 MLD (2.4 -2.9 MGD) of raw water is supplied to Ordinance factory in Khamariya. Water is supplied from Pariyat Dam through a 1371 mm (54") PSC line extending from an open canal. Water from Fagua Nallah is pumped from the Fagua pump house (with 1 pump of 150 HP, 2 pumps of 120 HP and 1 pump of 60 HP). About 9-10 MLD (1.9-2.2 MGD) water is supplied from the Fagua pump house.

#### *2.1.2.2 Treated water transmission and distribution*

The Ranjhi filter plant has an installed capacity of 54 MLD (11.9 MGD) but it is reported to be operating at 60-65% installed capacity (34 MLD/ 7.5 MGD). The treatment system consists of clariflocculators followed by sand filtration and disinfection. However the flocculators were observed to be out of use; only sand filtration and disinfection are provided for treatment. The details of distribution from the Ranjhi WTP are given in Table 2.2.

**Table 2.2** Details of distribution from the Ranjhi WTP

| Pump House | No./capacity of pumps | Areas serviced |
|---|---|---|
| Pump House 1 | 300 hp – 3 nos.<br>50 hp – 1 no.<br>35 hp –2 nos.<br>40 hp – 1 no. | Kulli Hill Tank, Vehicle factory (6.75 MLD/ 1.5 MGD), Gun Carriage factory (1.8 MLD /0.4 MGD), Engineering College (0.45MLD / 0.1 MGD) and to Shobhapur Colony, Dwarka Nagar and Siddhbaba Settlements. |
| Pump House 2 | 60 hp – 2 nos.<br>50 hp – 1 no. | Ranjhi Tank (2.25ML/ 0.5 MG) |
| Pump House 3 | 40 hp – 2 nos. | Bajrang Hill Tank (0.9 ML/0.2 MG) |

The Figure 2.3 gives a schematic layout of water transmission/ distribution from Ranjhi water treatment plant.

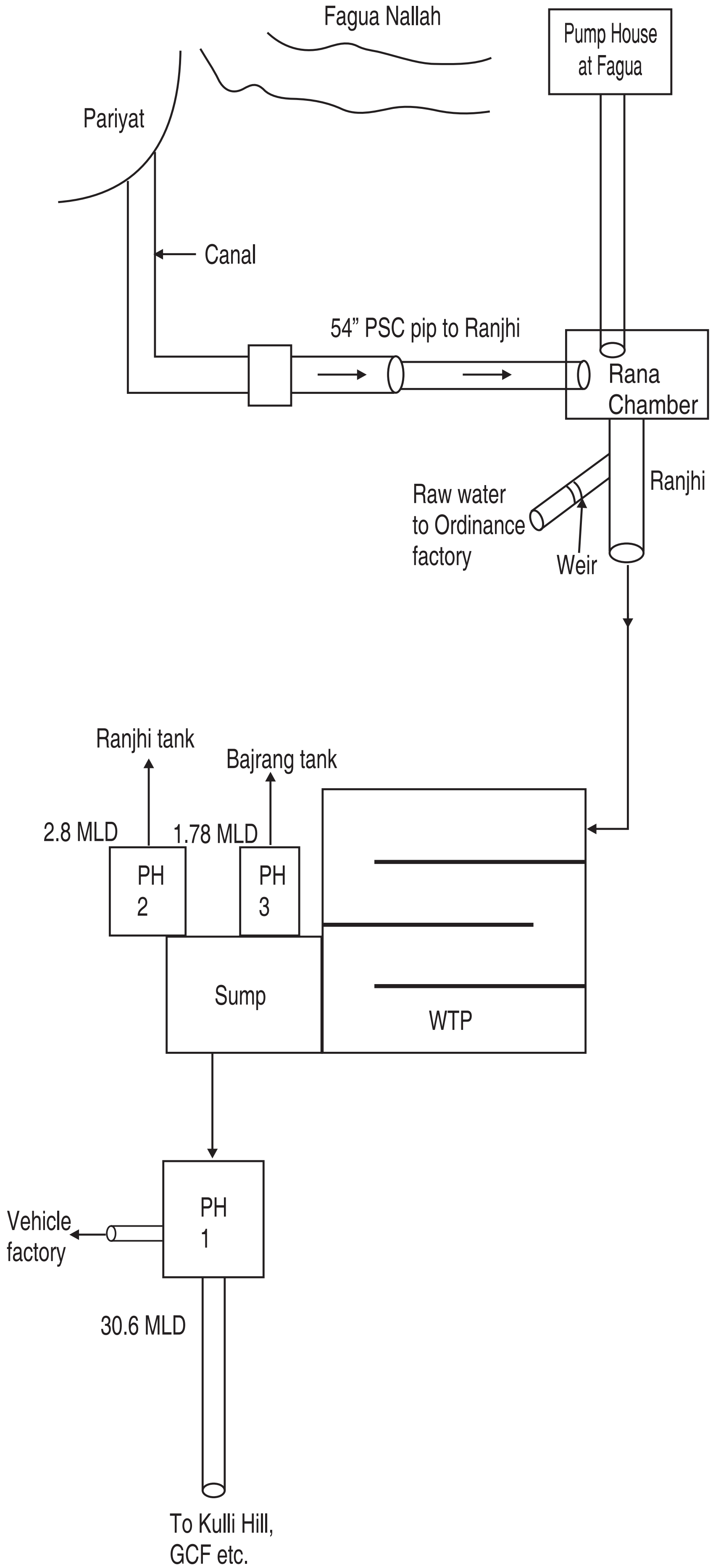



**Figure 2.3** Pariyat-Fagua system (Ranjhi treatment plant)

### 2.1.3 Narmada project

**Picture 2.1** Intake Well at Narmada River

#### 2.1.3.1 Raw water transmission

The Narmada river is the biggest source of water supply to the Jabalpur city. The flow in the river is regulated at the Bergi Dam located 22 km (13.7 miles) from the intake well (Picture 2.1) for the water supply scheme to the city. As per agreement with the MP Water Resources Department, 432 MLD (95.2 MGD) of water is allocated from the dam for water supply to the city. The current withdrawal is only 20% of the allocation, which indicates that availability of raw water in not a major problem. The GL of intake well is below the city level hence pumping is required to abstract raw water from the river. Water from Narmada is abstracted through a Jack well and pumped to the Lalpur water treatment plant.

#### 2.1.3.2 Treated water transmission and distribution

Water from the raw water pump house is pumped to the Lalpur water treatment plant through two rising mains of 650 mm Ø (25.6") and 700 mm Ø (27.5") respectively. The Lalpur water treatment plant has two units of 42 MLD (9.3 MGD) and 55 MLD (12.1 MGD). However the 55 MLD (12.1 MGD) is not working to full capacity and the total inlet flow to both the treatment plants was observed to be around 78 MLD (17.2 MGD).

The Figure 2.4 below gives a schematic layout of water transmission/ distribution from Lalpur water treatment plant.

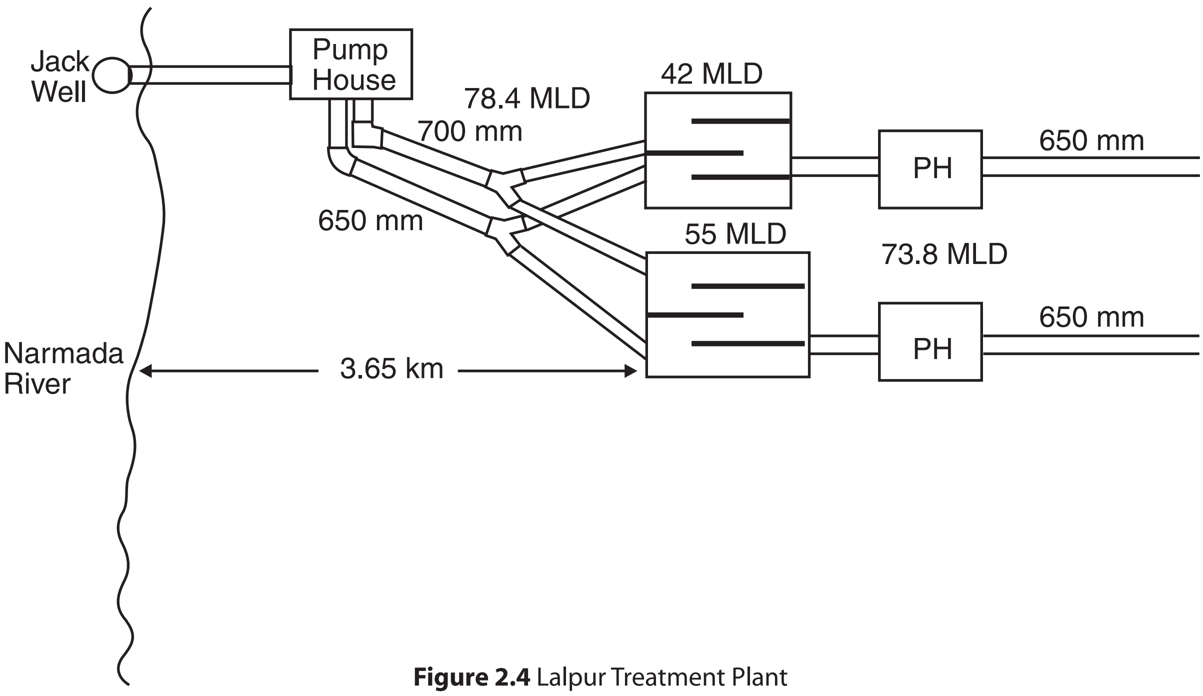



**Figure 2.4** Lalpur Treatment Plant

### *2.1.4 Unit I: 42 MLD (9.3 MGD)*

The 42 MLD (9.3 MGD) unit at Lalpur has two clarifiers and 6 units of rapid sand filter. The pumping is carried out through 6 pumps of 225 HP (3 operating at a time) through 700 mm (27.5") CI pipe. The plant caters to 9 OHTs in the distribution network on a twice daily basis as mentioned in Table 2.3 below:

**Table 2.3** Details of OHTs

| Reservoir | Capacity in ML (MG) |
|---|---|
| Gulavva taal | 2.25 (0.5) |
| Wright town | 2.25 (0.5) |
| Bhanwar taal | 2.25 (0.5) |
| Srinath ki taallaiya | 2.25 (0.5) |
| Town hall | 2.25 (0.5) |
| Laxmi pur | 2.25 (0.5) |
| Anand Nagar | 2.25 (0.5) |
| Kotwali | 2.25 (0.5) |
| Medical | 2.25 (0.5) |

### *2.1.5 Unit II: 55 MLD (12.1 MGD) unit*

The 55 MLD (12.1 MGD) unit is not fully operational and is currently working below its capacity. The plant has 3 clarifier units and 8 rapid sand filters. Two new OHTs are under construction, one near kotwali (2.3 ML/0.5 MG capacity) and one at Shyam Singh ka Garha (4.5 ML/ 1 MG capacity). This unit fills up 8 reservoirs on a twice-daily basis as mentioned in the Table 2.4 below:

**Table 2.4** Details of reservoirs

| Reservoir | Capacity in ML (MG) |
|---|---|
| Gupteshwar | 3.4 (0.75) |
| Dangal Maidan | 2.25 (0.5) |
| Madaar Chhalla | 2.25 (0.5) |
| Guarighaat | 0.9 (0.2) |
| Poli pather | 0.9 (0.2) |
| Civil lines | 0.9 (0.2) |
| Siddhbaba | 0.9 (0.2) |
| Kuli Hills (also serviced from Ranjhi) | 6.4 (1.4) |

### *2.1.6 Groundwater supplies*

In addition to the surface water sources around 27 MLD (6 MGD) of water is reportedly supplied from 415 MCJ tube wells spread across the city.

## 2.2 Distribution and consumption of water

Water from the four treatment plants is filled into 20 OHT's and then it is supplied to the consumers. In addition the tubewells and the Bhongadwar WTP also directly supply water to the consumers. The average pressure maintained in the distribution network is around 25-30m (2.5-3 $Kg/cm^2$). The pressure at the WTP pumping mains (for treated water) is around 60-80m (6-8 $Kg/cm^2$). Though pressure gauges are available at some locations, studies to understand the existing pressure in these sections of the network have not been carried out / reported. Total number of domestic connections and bulk connections in Jabalpur city as per MCJ records is 44,237 and 485 respectively.

### *2.2.1 Public stand posts*

In addition, water is also supplied through public stand posts, which are located unevenly at different places in the city. As per GHK report, public stand posts provided in the town are about 34% of the individual house connections, which comes to be around 15,040.

### *2.2.2 Illegal connections*

The exact number of illegal connections in Jabalpur city is not known, but based on the figures provided by MCJ, total number of illegal connections in Jabalpur are estimated to be around 15,000.

### *2.2.3 Tanker supplies*

Water is supplied through tankers to various areas of Jabalpur city. The water for these tankers is drawn from all the supply networks. About 14 tankers supply water to the city, of which 6 are truck tankers and 8 are tractor tankers. Total water supplied through tankers comes to be around 0.15 MLD (0.03 MGD). Though the tankers supply drinking water, the water is also used for other daily activities like washing and bathing leading to an overall shortage, in supply.

### *2.2.4 Water metering: Bulk and domestic connections*

During the field visits conducted by the team, it has been observed that there is practically no metering in the entire systems. Although meters are installed at many places at the consumer end, but most of them are not in working condition. Only few of the bulk revenue meters are functional.

## 2.3 Upcoming augmentation projects

Currently there is plan to add a new treatment plant to Bhongadwar treatment plant with a capacity of 13.6 MLD (3 MGD). Water to this treatment unit will be supplied from Khandari-Gaur system. In addition there is also a proposal to rehabilitate the existing WTP and also the raw water transmission mains from Khandari to Bhongadwar.

## 2.4 Key issues

Based on the site investigations and flow monitoring carried on at Jabalpur, the following key issues can be identified:

- The current system for recording basic information on flows, connections, sources, etc. is highly unorganized and inaccurate. As a result, the information available from different sources when compared is ambiguous and contradictory. This makes the process of water balance analysis prone to a high degree of error.

- There is practically no infrastructure to measure the amount of water in the network. Although some provisions are made at consumer end, but not maintained properly. No provisions have been made to measure flow at supply side.

- Updated information on available infrastructure like the size and length of pipe and the provision of valves is also inadequate. This complicates the process of flow analysis and measurement. As most of this information is not documented properly, the analysis relies only on estimates provided by the officials and these estimates vary from person to person.

- Pressure in different sections of the water supply network is not measured and only estimates of the flow are available.

- The demarcation of the city into different zones has been done on an administrative basis. It has been observed that water in one zone is supplied from reservoirs located across different zones. It is important to realign zones on hydraulic principles which ensure minimum head loss as well as facilitate improved management.

It is thus clear from the preliminary investigation that lack of data/information is one of the key challenges for implementation of WDM in Jabalpur. Further the general orientation of MCJ does not promote efficiencies. It is thus imperative that the WDM programme must be cross cutting and include strategies, which include technical, institutional and financial reforms in a holistic manner.

# 3 Rapid Water Balance Assessment

One of the key issues facing water supply operations in Jabalpur is the high level of inefficiencies in the distribution system and lack of datasets for carrying out improvements in it. Further as mentioned earlier no water balance exercise has ever been carried out before for Jabalpur city and the water managers thus have little idea of the volume of water into and out of the system. A water audit and balance will help in establishing total system input volume and various components of the water distributed i.e authorised consumption, water losses, pilferages etc. Such an exercise would enable the utility to establish the total water balance (Table 3.1) and also decide upon strategies for identifying the sources of losses in the system and designing appropriate WDM strategies.

However based on the current data availability and the limited scope of the assignment it is practically impossible to carry out a water balance with reasonable accuracy levels. Thus the water balance exercise has been carried out based on certain assumptions, which may be refined by MCJ in due course of time. The exercise would serve as a starting point for MCJ and help in developing an approach to carrying out a water balance exercise in future course of action.

## 3.1 Approach & methodology

Water auditing and balancing exercise for Jabalpur has been carried out to determine components of the standard IWA (International Water Association) water balance using the traditional top down approach. Aqualibre water balance software version 1.15 developed by Ronnie Mckenzie has been used for calculating water balance.

### *3.1.1 IWA standard water balance*

As mentioned above the IWA standard water balance methodology has been used for water balance estimation in Jabalpur. The methodology essentially aims at balancing the inputs to the systems with the outputs through measurement of various components as depicted in Table 3.1.

- System input volume: it is the volume of water input to a transmission system or a distribution system.
- Authorized consumption: it is the volume of metered or unmetered water taken by registered consumers, 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.
- Water losses: system input volume – authorized consumption.
- Real losses: These refer to the physical water losses from the pressurised systems, upto the point of customer metering.
- Apparent losses: It consists of unauthorised consumption and all types of inaccuracies associated with metering.
- Non-revenue water: it is the difference between the system-input volume and billed authorized consumption.

**Table 3.1** IWA standard water balance

| A | B | C | D | E |
|---|---|---|---|---|
| System input volume M$^3$/year | Authorized consumption M$^3$/year | Billed authorized consumption M$^3$/year | Billed metered consumption (including water exported) M$^3$/year | Revenue water M$^3$/year |
| | | | Billed unmetered consumption (M$^3$/year) | |
| | | Unbilled authorized consumption | Unbilled metered consumption (M$^3$/year) | Non revenue water M$^3$/year |
| | | | Unbilled unmetered consumption (M$^3$/year) | |
| | Water losses M$^3$/year | Apparent losses | Unauthorised consumption (M$^3$/year) | |
| | | | Metering inaccuracies (M$^3$/year) | |
| | | Real losses M$^3$/year | Leakage in transmission and distribution mains (M$^3$/year) | |
| | | | Leakage and overflow from storage tanks (M$^3$/year) | |
| | | | Leakage on service connections upto point of metering (M$^3$/year) | |

The steps to be followed for calculating Non-Revenue Water and Water Losses are:

Step 1: Define System Input Volume and enter in Col. A.

Step 2: Define Billed Metered Consumption and Billed Unmetered Consumption in Col. D; enter total in Billed Authorised Consumption (Col. C) and Revenue Water (Col. E).

Step 3: Calculate the volume of Non-Revenue Water (Col. E) as System Input Volume (Col. A) minus Revenue Water (Col. E).

Step 4: Define Unbilled Metered Consumption and Unbilled Unmetered Consumption in Col. D; transfer total to Unbilled Authorised Consumption in Col. C.

Step 5: Add volumes of Billed Authorised Consumption and Unbilled Authorised Consumption in Col. C; enter sum as Authorised Consumption (top of Col.B).

Step 6: Calculate Water Losses (Col. B) as the difference between System Input Volume (Col.A) and Authorised Consumption (Col. B).

Step 7: Assess components of Unauthorised Consumption and Metering Inaccuracies (Col. D) by best means available, add these and enter sum in Apparent Losses (Col. C).

Step 8: Calculate Real Losses (Col. C) as Water Losses (Col. B) minus Apparent Losses (Col. C).

Step 9: Assess components of real losses (Col. D) by best means available (night flow analysis, burst frequency/flow rate/duration calculations, modelling etc), add these and cross-check with volume of Real Losses in Col. C which was derived from Step 8.

As is evident from the section the entire water balance is dependant on the quality of information of which meter readings form the most crucial input. Accuracy of the water balance is thereby directly proportional to the level and reliability of the available information. In context of Jabalpur the lack of data sets especially related to the metering/quantum of water in the system has been a major bottleneck for carrying out water balance exercise with reasonable accuracy.

In the absence of reliable datasets, water balance exercise has been carried out through limited flow monitoring using portable ultrasonic flow meters and making assumptions wherever datasets were not available. Current water balance exercise should serve only as a starting point and an accurate water balance should be derived over a period of time after all necessary information is generated on a regular basis.

Most of the available information is in the form of a crude estimate, so as a first step the information collected from MCJ was analysed and validated to improve the reliability of the information. In addition limited flow-monitoring exercise was carried out in the bulk transmission network to draw upon the accurate figures for the total system input volume. Flow monitoring was carried out using ultrasonic flow meters at the inlet and outlet of treatment plant, wherever possible. In addition flow/discharge was also measured in open channels using crude method like the ball method to have a fair idea.

The water balance has been carried out using the information made available by MCJ, flow measurements and discussion with MCJ engineers. The sections below describe the field observations and assumption used for water balance calculations.

## 3.2 Field observations

### *3.2.1 Lalpur treatment plant supply*

Water from Narmada River is supplied to two treatment plants with capacity of 42 MLD (9.25 MGD) and 55 MLD (12.11 MGD). Flow monitoring was carried out at the inlet and outlet of both the treatment plants. About 78.5 MLD (17.3 MGD) of raw water is supplied to these treatment plants from Narmada and 73.8 MLD (16.25 MGD) was measured at the outlet of the treatment plant. The remaining volume of water accounts for treatment losses, which is nearly 5.9 %.

On the distribution side, water is supplied to 14 OHT’s from Lalpur WTP and all these tanks are filled, both in the morning as well as in the evening. Total water supplied to these OHT’s is estimated to be about 50 MLD (11 MGD) (based on the tank filling records provided by MCJ). A number of illegal connections (around 20 nos.) have been reported on the transmission mains from Ghamapur area, which does not have any tap to close and hence there is severe wastage of water as the supply from rising main is 24-hours. As per the authorities, rate of water flow from these stand-post are 10 litres per minute. Hence, the total amount of water lost from these taps is estimated to be around 0.5 MLD (0.11 MGD).

### *3.2.2 Ranjhi treatment plant supply*

Water from Pariyat Dam and Fagua Nallah is supplied to Ranjhi water treatment plant. Around 35.7 MLD (8.25 MGD) of water flow was measured near the outlet of the treatment plant, which includes 9.45 MLD (2 MGD) to bulk consumers and remaining to domestic consumers through OHT's. Water is pumped from three-pump houses; pump house 1 supplies around 30.6 MLD (6.75 MGD) of water to Gun Carriage factory, vehicle factory and domestic consumers. Water supplied from Pump house 2 and 3 is approximately 2.83 MLD (0.62 MGD) and 1.786 MLD (0.4 MGD) respectively. Apart from these 0.45 MLD (0.1 MGD) of water is also supplied to SAF Battalion.

### *3.2.3 Bhongadwar treatment Plant supply*

Khanduri Dam and Gaur River supplies water to Bhongadwar treatment plant. Around 27 MLD (6 MGD) of water is supplied from these sources, although during monsoon season water is supplied from Gaur River only. Major leakage is evident in the pipeline carrying water from Khaduri Dam. Considering these leakages, total water supplied from Bhongadwar treatment plant estimated to be around 22 MLD (5 MGD). Water from this treatment is directly supplied to most of the areas and hence accountability of water is difficult in this case, although an attempt has been made to analyse the total water consumed from Bhongadwar treatment plant based on population. Total water supplied directly to the consumers is estimated to be around 5.3 MLD (1.63 MGD). Water from Bhongadwar WTP is also supplied to MES, Belbag tank and areas like civil lines, Gorakhpur and Haubagh etc.

### 3.2.4 Groundwater supplies

Groundwater supplies in the Jabalpur city is estimated to be 20 MLD (4.4 MGD) through 415 tube-wells. Tubewells either supply directly to the consumers or through OHT's. As per the authorities, 27 MLD (6 MGD) of water is supplied through tubewells. Out of which, 0.3 MLD (0.06 MGD) of water is supplied to consumers through OHT's and the remaining amount is supplied directly to consumers.

Table 3.2 summarises the observed flow and losses in different stretches of the supply system.

**Table 3.2** Observed flow and losses in supply network based on supplies from 3 WTP

| S. No. | Water source | Quantity (in MLD) | Quantity (in MGD) | Remarks |
|---|---|---|---|---|
| **Supply side** | | | | |
| ***Lalpur Treatment Plant*** | | | | |
| 1 | Total Capacity of 2 WTP at Lalpur (42 MLD + 55 MLD) | **97** | 21.37 | |
| 2 | Inlet at Lalpur(42 MLD + 55 MLD) | **78.5** | 17.3 | Discharge measured at the inlet pipes of both treatment plant |
| 3 | Outlet at Lalpur(42 MLD + 55 MLD) | **73.8** | 16.26 | Discharge measured at the outlet pipes of both treatment plant |
| ***Ranjhi Treatment Plant*** | | | | |
| | **Inlet** | | | |
| 1 | Pariyat Dam | **30** | 6.61 | As reported by MCJ |
| 2 | Faugua Nallah | **9** | 2 | ,, |
| | **Outlet** | | | |
| 3 | Pump House No 1 | **30.64** | 6.75 | Discharge measured using ultrasonic flow meters |
| 4 | Pump House No 2 | **2.83** | 0.62 | ,, |
| 5 | Pump House No 3 | **1.78** | 0.4 | ,, |
| 6 | SAF Battalion | **0.45** | 0.1 | From MCJ |
| ***Bhongadwar Treatment Plant*** | | | | |
| 1 | Water from Khanduri dam / Gaur River to WTP | **27** | 5.95 | Capacity of treatment plant |
| 2 | Water supplied from WTP | **22.25** | 4.9 | Considering losses in treatment and transportation |
| **Total treated water supplied** | | **131.8** | 29 | |
| ***Groundwater supplies*** | | **20** | 4.4 | |

## 3.3 Water balance calculations

Water balance has been carried out using the Aqualibre (Ver 1.15) water balance software which calculates the water balance based on input data. The software has standard values of certain parameters, which have to be used in case data is not available. The software also calculates the probable percentage of error in the calculations based on the reliability of information being fed into the software.

To carry out the water balance following assumptions have been used with the best available information and in consultation with MCJ and Design Supervision Consultants (DSC) for the project.

1. Decadal population growth rate is assumed to be 10% over 2001 population.
2. Treatment losses are assumed to be 5%.
3. Total water supply from the treatment plants is 131 MLD (28.85 MGD).
    a. Bhongadwar WTP: 22.25 MLD (5 MGD) (error 10%).
    b. Ranjhi WTP: 35.71 MLD (7.86 MGD) (error 5%).
    c. Lalpur WTP: 73.82 MLD (16.25 MGD) (error 5%).
4. Water supplied from Tube wells is estimated to be 20 MLD (4.4 MGD) (error 20%). Tubewell supply has been calculated assuming 415 tubewells operating at 8172 litres per hr for 8 hr (1800 gallons per hr for 8 hrs) a day with pumping efficiency of 70%.
5. Consumption by bulk consumers is reported to be 13.8 MLD (3 MGD) (error 5% for metered bulk consumers and 15% for un-metered bulk consumers).
6. Domestic supply from OHT tanks filled is reported to be 75.6 MLD (16.65 MGD) (error 5%). Another 0.3 MLD of water is fed from tubewells to OHTs.
7. Supply from public stand posts is estimated to be 2.8 MLD calculated assuming 4829 stand posts, serving 3 families each at the rate of 20 lpcd (error 30%) (as reported by MCJ).
8. Supply from tankers per day is 0.158 ML (0.035 MG) (error 25%) (as reported by MCJ).
9. Daily losses as percentage of bulk storage is 0.25% and percentage time these tanks are under pressure is assumed to be 25%.
10. Pressure in the system is assumed to be at 3m (error 15%) (as observed).
11. Average trunk pressure in the system is assumed to be 30 m (3kg/cm$^2$) (error 15%).
12. Length of trunk mains reported and estimated as 63 km (error 20%).
13. Length of distribution network reported 480 km (error 30%).
14. Total number of domestic connections is reported to be 46,969 (error 10%).
15. Default leakage values as in the software are used for background leakages.
16. Average distance between distribution line and house is 1.5 m (5 ft) (error 30%).
17. Leakage in properties is enabled while estimating leakages beyond property line, as in Aqualibre software.

Details of water balance calculations are discussed in subsequent paragraphs.

## 3.4 Water balance software

The IWA Water Balance model calculates major forms of water consumption and water loss encountered in drinking water utilities. It also has a set of rational performance indicators that evaluate utilities on system-specific features such as the average pressure in the distribution system and length of water main. These features allow water utilities to make a meaningful assessment of water loss in the system, benchmark themselves with other water utilities and set performance targets. The model tells us how much of each type of loss that occurs in the water utilities. The key concept around this method is that no water is "unaccounted-for". All water supplied is accounted for in the components listed by using either measured or estimated quantities. Standard IWA water balance and figures for the estimated values for Jabalpur is given in Figure 3.1.

### *3.4.1 Calculated values for Jabalpur water balance*

Absence of data on leakages and reliability of the basic data has been a major concern in the calculations. The audit is therefore based on the best information available from different sources, which tends to be a mixture of assumptions that shall need formal vetting by the officials of MCJ in due course. Based on these preliminary audit calculations done using AQUALIBRE software, following conclusions can be drawn:

1. There is a huge uncertainty in the final results on account of the poor quality of information and its comprehensiveness.
2. It is estimated that authorised billed consumption is 66 % of the total supply but most of this consumption is unmetered raising an eyebrow on reliability of this information.
3. Non-revenue water is estimated to be between 37% and 43%. The likely error in calculated value for NRW is ±15%.

Error percentage in calculation of all the values stated is given with the calculations from the software attached as Annexure 3.1. The calculated results here give an overall indication of existing trends and areas of improvement.


**Figure 3.1** Standard IWA water balance

# 4 Water Demand Management

## 4.1 Introduction

To ensure long-term sustainability of water resources the focus of water management needs to shift from a traditional supply side management to demand side management, which has traditionally been neglected. Though augmentation of supplies would be required to meet the growing demand in urban centres, the future lies in effectively controlling our demand for water resources and efficiently managing and using the available resources. The approach calls for the development of a water demand management strategy, which would aim at reducing the losses in the system (UFW), improving operational efficiencies, promoting rationale use of water resources, equitable distribution of the resources and exploring alternative sources such as recycling of wastewater for non-potable uses. Implementation of such an approach would require reforms in terms of providing adequate regulatory, institutional and legal framework for delivery of services; tariff reforms which ensure financial sustainability of operations of the utility and; internal reforms within the utility which aim at improving the operational efficiencies and reducing UFW (Unaccounted-for water) to acceptable levels.

Water demand management refers to the implementation of policies and/or measures, which serve to control or influence the amount of water used and thereby lead to improved efficiency in production, transmission, distribution and use of water. The demand management approach differs from traditional supply-oriented approaches, by placing its emphasis on improved management of existing systems rather than augmentation of supply. It also makes use of social and economic policies to influence how efficiently water is used. This approach promotes optimum utilization of the available water resources through increased consumer awareness and better operational efficiency at the level of service provider. WDM should be viewed as complementing the supply management efforts and not replacing them. Economic instruments such as effective water pricing and increased consumer awareness are also an integral part of the WDM concept apart from the technical measure aimed at reducing losses.

Jabalpur's water supply scheme draws about 130 MLD of raw water for treatment while covering an estimated population of about 12.3 lakhs. Besides there is a withdrawal of groundwater to the tune of 20 MLD through a system of tube wells. The overall availability of water supply to Jabalpur from the sources is around 152 MLD, which translates into a per capita availability of 123 lpcd considering no losses and equitable distribution. However in the actual situation it is much less with estimated per capita availability of around 80-90 lpcd. Further most of the city gets only 2-3 hours of water supply in a day with little reliability. The problem can be attributed more to the lack of infrastructure and current management practices rather than the lack of water availability to the town. Water demand management is thus a tool, which can be used to improve the efficiency of the current system. This chapter discusses specific WDM strategies, which if implemented in Jabalpur will go a long way in ensuring sustainable and equitable water supply to the city.

Water demand management strategies can be broadly categorised and discussed under three heads: Technical, Financial and Institutional. Accordingly, this report discusses the proposed strategies and their implementation plan as individual Chapters 4, 5 and 6.

A systems approach has been adopted while formulating different WDM strategies for Jabalpur. Implementation of the proposed WDM strategies needs to be undertaken in a phased manner, as this shall require bringing in some changes in the existing framework & scheme of operation. Further there is a need to bring consensus on proposed changes for an effective implementation. Short-term actions should ideally be implemented within 2 years time and shall create a foundation for medium-term and long-term actions. Medium term actions need to be implemented within next 2 years of the implementation of short-term actions. Time frame for implementation of long-term actions could be decided on the basis of experiences and lessons drawn from the earlier phases of implementation. It is well realised that implementation of these strategies shall face different obstacles, which have been identified and an approach to address the same has also been recommended. The relevant institutions and stakeholders to be involved in the process of implementation are also identified. Some of these strategies[1] need to implemented on a pilot scale and then replicated on a larger scale after incorporating lessons and best practices learnt in the process. It is further recommended that a Plan-Do-Check-Act (PDCA) approach, as shown in Figure 4.1, should be followed for implementation of the recommended strategies. A total of 10 strategies have been discussed below, in addition recommendation on financial, institutional and policy reforms have also been suggested in the subsequent chapters.

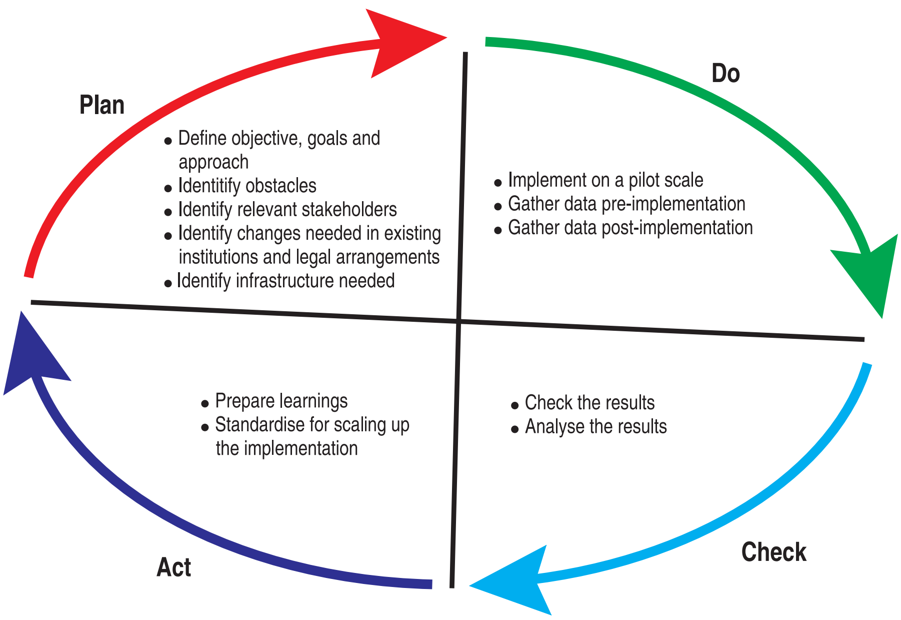



**Figure 4.1** PDCA Approach

[1] Not in any order of priority.

# 5 Water Demand Management Strategy: Technical

Technical WDM strategies described in this chapter essentially includes actions such as metering, sectorisation, water auditing, leak detection and control, GIS, DMA and so on. All the above would help in improving the efficiency of water distribution. In addition tools such as GIS and approaches like establishment of DMA would also facilitate implementation of advanced techniques such as pressure management, night flow analysis etc in the long run.

## 5.1 Metering

Accurate information on the quantity of water in and out of the system is paramount to track and control operational efficiencies as it would help in identifying and prioritising actions needed to reduce losses. One of the biggest problems facing water supply operations in Jabalpur is lack of information on the amount of water entering the system and consumed. Lack of metering/flow measurement is one of the major reasons for the current state of affairs.

In the above context, metering of water flows at the transmission, distribution and consumer end is one of the most important aspects of demand management. Metering of water flows is done basically for three purposes:

- To measure the supply and consumer demand
- To calculate water balance
- To determine water loss

Though traditionally most of the Indian cities did not have metering over the last decade, the importance of metering is being realised and many of the cities have installed both bulk management as well as revenue meters. Bangalore, Hyderabad, Chennai are some examples of the same.

### Type of meters

Water meters are available in size varying from 50 mm to over 1500 mm or even more depending of diameter of pipes. Mainly three types of meters are used for measuring bulk flows:

1. Turbine meters
2. Electromagnetic meters
3. Ultrasonic meters

Table 5.1 gives a comparative analysis of various types of meters.

Details of various types of meters are provided in Annexure 5.2a.

The following section recommends the implementation plan for different sets of metering in the water supply network. Annexure 5.1a highlights the proposed activity schedule for implementation of this strategy.

From a management perspective, meters may be divided into Management meters and Revenue meters. While the former are used for the purpose of water balancing and management including estimation of losses the latter are used for recording the actual quantity of water used by consumers. The sections below detail out strategies for both management and revenue metering.

**Table 5.1** Types of Water Meters

| Characteristic | Mechanical Meter | Electromagnetic Meter | Ultrasonic |
|---|---|---|---|
| Straight pipe | Typically 3 pipe diameters before meter | Typically 5 to 10 pipe diameter before and after meter (can vary) | Typically 5 to 10 pipe diameter before and after meter (can vary) |
| Power supply | No power | Power required (Batteries) | Power required (Batteries) |
| Uninterruptible Power Supply required? | No | Yes | Yes |
| Pressure loss | Low pressure loss | Zero pressure loss | Zero pressure loss |
| Accuracy | Very good | Extremely good (Except maybe for insertion type) | Very Good |
| Will air affect accuracy | Yes | Yes | Yes |
| Strainer ?? | Yes | No | No |
| Isolating Valves required? | Yes | No | No |
| Level of skill to fix meter | Low skill | High skill | High Skill |
| Remote sensing connecting | Can be connected. Converter and power required | Can be connected | Can be connected |
| Lightning /Surge Protection | Not required | Can be damaged | Can be damaged |

**Source:** Daniel Meyers, 2006

Ultrasonic | Electromagnetic | Mechanical/Turbine

**Source:** Daniel Meyers, 2006

**Picture 5.1** Types of water meters

## A. Bulk management meters

Bulk management meters are used for accounting the water flow in different reservoirs and are informative for water balancing. Bulk meters may be installed at various strategic locations in the entire network which may help in estimating the total volume of water at any given point of time and also estimating losses in the transmission/distribution mains.

**Picture 5.1a** Pipeline from Khandari Dam to Bhongadwar treatment plant

### Implementation plan

***Short term***

1. It is proposed that in the first stage of implementation bulk meters should be installed at the inlet from Khandari & inlet from Gaur. This should however be undertaken after the replacement of the existing pipelines. Bulk meters also need to be installed at four outlet pipes from Bhongadwar treatment plant (Table 5.2). The bulk management meters to be installed are of electromagnetic types. An example of such a meter installed in Bangalore is given in Picture 5.2.

**Picture 5.2** Electromagnetic flow meter installed in Bangalore

2. Outlets from the Lalpur treatment plants (42 & 55 MLD) and the three pump houses from the Ranjhi treatment plant should be provided bulk meters. Similarly the pump house supplying to the High court should also be provided bulk meter for open channel that carries water from Pariyat to the Ranjhi treatment plant, it is proposed that V-Notches or Level Gauges should be installed to monitor the flow as well as to ensure efficient supply to treatment plant by comparing inflow and outflow.
3. Low cost metering options like V-notches and level gauges should be installed at locations like open channels to support the data base. For instance, a combination of a V-notch (at the inlet of WTP) and bulk flow meter (at WTPs outlet) can help in knowing accurately the extent of water lost in treatment, which can then be related with possible causes like changes in the quality of raw water at the source or concentration of contaminants or the efficiency of treatment process.
4. It is suggested that the reliability of installed meters be ascertained before implementation on a wider scale. Therefore bulk meters approved by agencies like FCRI (Fluid Control Research Institute), CWRPS (Central Water and Power Research Station), IDEMI (Institute for Design of Electrical Measuring Instruments) etc. should be installed. It is also advised to install meters capable of data logging using standard logging equipment and documentation done properly. A proper maintenance and calibration schedule should be worked out for bulk meters.
5. It is necessary that MCJ formulates a calibration and maintenance schedule for all bulk meters in association with the manufacturer or supplier of these meters. Another alternative is to sign an annual maintenance contract with the manufacturer/supplier for the upkeep of these bulk meters.
6. MCJ should consider purchasing portable flow meters for measuring flows at different intermediate locations so as to assess losses in any particular stretch. This can be used to detect any major leaks in the systems. However since normally the accuracy of ultrasonic potable flow meters is between 5-10% this cannot be used to accurately measure the losses in the system.
7. Level gauges should be installed for flow monitoring at the water reservoirs. Regular monitoring of flow in pipes through portable flow meters will assure reliability of measurement from level gauges. It is recommended that all faulty level gauges be replaced within 2 years. This shall be useful for estimating water flow in and out of all reservoirs and shall also help in avoiding overflows,

if any. Hydraulically controlled valves may also be installed at inlet of the reservoirs. These valves will automatically close if the reservoir level reaches a certain level- thereby preventing water losses and also avoiding manual operation.

8. Level gauges made of corrosion resistant material should be installed for an increased life. Proper selection of material is necessary, as corrosion of the level gauge due to the presence of chlorine has been observed in the past. There should be a possibility that these level gauges could be logged using standard logging equipment.
9. Location of bulk meters should be marked on GIS maps with regular updation of maps, including any changes in adjoining roads and pipe networks.
10. The existing procedures for documentation of water flows also need a re-look. Information from all locations, where bulk metering is done, should be compiled centrally (in electronic form) and analyzed regularly for variations in flow, losses in different stretches and discrepancies in recorded/ reported values.
11. There is also a need to change the mindset regarding the significance of metering water flows. Capacities should be built for proper upkeep, calibration and troubleshooting related to the operation of all bulk-metering infrastructure (bulk meters, V notches, portable meters and level gauges). There is also a need to change the current attitudes towards the significance of metering water flows.
12. All new augmentation schemes should be planned in light of the information generated from the bulk metering exercise. Adequate provisions should be made for metering the flow in all new augmentation and upgradation projects. Also advisable is to ensure the compatibility of the bulk meter with the slope of the area (pipeline) where it is installed.
13. Further all management meters must be connected to an online logging device to enable electronic data transfer to a database management system.

Table 5.2 depicts the proposed locations for bulk metering of the flow (in short term). Annexure 5.2 (a-d) lists details of different kinds of meters and the guidelines for their procurement, installation and calibration[2] .

**Table 5.2** Proposed locations for bulk metering of flow (Bulk management meters)

| Location | No. of meters | Size of pipe | Flow measurement using | Type |
|---|---|---|---|---|
| Inlet from Gaur to Bhongadwar | 1 | 600 mm (24”) | Bulk meters | Electromagnetic |
| Inlet from Khandari to Bhongadwar | 1 | 600 mm (24”) | Bulk meters | Electromagnetic |
| Outlet of Bhongadwar WTP | 2 | 300 mm (12”) | Bulk meters | Mechanical |
| | 1 | 800 mm (30”) | Bulk meters | Electromagnetic |
| | 1 | 400 mm (16”) | Bulk meters | Mechanical |
| Outlet from Lalpur (42 MLD) WTP | 1 | 800 mm (30”) | Bulk meters | Electromagnetic |
| Outlet from Lalpur (55 MLD) WTP | 1 | 800 mm (30”) | Bulk meters | Electromagnetic |
| Ranjhi Pump house-1 [(Vehicle factory) & (Kulli hill,GCF etc)] | 2 | 300 mm (12”) | Bulk meters | Mechanical |
| Ranjhi Pump House-2 (to Ranjhi OHT) & Ranjhi Pump House-3 (to Bajarang Nagar Tank) | 2 | 100 mm (4”) | Bulk meters | Mechanical |
| High Court Pump House | | | Bulk meters | Mechanical |

[2] The list is not comprehensive yet could serve to be a good starting point for judicious selection of meters.

***Medium to long term***

1. At a later stage, in the 2nd phase, meters should be installed at the inlet/outlet of select storage reservoirs and tube wells depending on local supply schematics. These locations should be representative of the entire infrastructure and should facilitate analysis of information on groundwater withdrawals and health of storage infrastructure like OHTs, GSRs and sumps.

2. In a long term, MCJ should also invest in installing bulk meters at the out let of major water storage tanks in order to measure flows and carry out water balance. Electronic open channel flow meters may be installed to measure the discharge at the inlet channel.

3. All the reservoirs must be connected to an online telemetry system wherein the reservoir levels can be transmitted (in real time) to a central computer. This will help in avoiding manual checking of reservoir levels and also help in planning for daily activities. Further the online data logging system for flow metering devices may also be connected to the same telemetry system.

## B. Bulk revenue meters

These meters are used to record flow that provides inputs for generating bills. Currently revenue from different bulk consumers, commercial and industrial consumers is realised on the basis of estimated flows. Municipal Corporation of Jabalpur earns around 80% of its revenue from bulk consumers. Thus it is very important to measure accurately the total consumption by these consumers.

Bulk consumers like MES, Defence Vehicle factory, SAF Battalion, GCF (Gun Carriage factory), Engineering college, etc. consume around 13.8 MLD of the total water supplied and pay a high percentage of the total revenue realised. It is necessary that the flow supplied to bulk consumers be measured accurately and billing be done realistically. Moreover, there is no difference between commercial consumer and industrial consumer, MCJ supplies water to both of them at the same rate. Thus it is recommended that a survey of all bulk consumers are undertaken to ascertain the status of existing meters and a suitable implementation may be drafted which would include checking, calibration, replacement and installation of new meters. This exercise shall be useful to impress conservation at the end of these bulk consumers and shall also improve the revenue realised from these sources. There is also a possibility that resulting conservation by bulk consumers will generate additional water resources that could be diverted to the water scarce regions/uncovered areas of Jabalpur. This would thus check inequitable distribution of domestic water supplies.

### Implementation plan

***Short term***

1. There is a need to redefine the existing definition of bulk consumers. Currently the definition is based on the revenue realised from these consumers. It is however recommended that a selectively categorised and redefined list should be made that covers all consumers withdrawing bulk volumes of water. Accordingly the proposed list should also include domestic consumers drawing water at one point before supplying to their respective inhabitants.

2. It is recommended that revenue meters should be installed at the inlet of all bulk consumers including those consumers, which would be covered after redefining the bulk consumer's status. The cost of the meters and their installation should be borne by the respective consumer. MCJ should formulate a list of approved specifications and manufacturers from which the consumers may directly buy meters. Installation, maintenance and calibration of these meters should be on mutually decided terms. Water losses on downstream of the installed meter should be a responsibility of respective consumer. MCJ can however provide guidance to the bulk consumers on tapping losses and wasteful use.

3. A phasewise strategy should be undertaken in which all connections above 3" may be metered in the first phase and connections smaller than 3" may be covered in second phase.

4. MCJ could consider signing a 3-5 year agreement with these bulk consumers for assured supplies to them based on their current and likely demands. Such an agreement could also cover some clauses on quality of service by MCJ and should ensure 100% revenue realisation.

***Medium term***

In the medium term, all non-domestic connections should be metered.

## C. Domestic consumer meters

In Jabalpur though a large number of the domestic consumers have meters installed, most of them are non-functional. The entire revenue is realized on a flat rate basis. As discussed in the section on financial analysis such a form of billing is irrational and not only encourages wastage but also leads to inequities in water supplies. Further, with such a billing approach, no one considers water to be an economic good and engages in wasteful use. The absence of metering coupled with an irrational tariff structure results in huge losses to the service provider, which leads to inadequate funds for proper O&M. But at the same time, MCJ should ensure adequate supply to its consumers before taking any initiation on domestic metering.

Experiences from reforms in the electricity sector indicate that metering and tariff rationalisation is the basic premise for effective demand management. Accordingly different service providers like Bangalore Water Supply and Sewerage Board, Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) have metered all of their consumers and rationalised tariff structures enabling better water management, effective service delivery and greater financial sustainability of their operations. Annexure 5.1b highlights the proposed activity schedule for implementation of this strategy.

Areas recommended for pilot study are mentioned below:

1. Brahman Mohalla at Medical area with about 300 households can be considered for pilot study area. The area is discrete, does not have tube well supplement and is supplied with stand posts.

2. Area Behind Bhanwartal garden, which is supplied by 200 connections.

3. Satyanand vihar, which has 70-80 households.

**Implementation plan**

***Short term***

1. Representative pilot areas need to be identified in select water supply zones where domestic meters can be installed and their performance be monitored properly. MCJ could consider identifying 3-5 areas, preferably in different zones, for such pilot implementation. The pilot area identified for such implementation should be selected judiciously in line with the following recommendations:

    - The pilot area should have high revenue realisation so as to also assess the financial viability of metering water supplies.

    - The source of water to the selected pilot area should ideally be from a single pipe connection fed from reservoir/OHT/Booster pumps.

    - Pilot area should have adequate water supply.

- Adequate cooperation from households where meters are installed like openness to the idea of metering, willingness to pay for better service, and facilitation of round-the-clock access to monitor individual meters and consumption patterns.

2. During the pilot phase, the water utility should consider installing different makes of domestic meters to assess their reliability and suitability for the local conditions. However simultaneously meters that are not functioning may be repaired/replaced. Installation practices should be standard.

3. A list of approved manufacturers should be prepared based on the experience of MCJ and subject to review of the accreditations provided by agencies like FCRI, CWRPS and IDEMI etc. To facilitate a speedy and appropriate installation, the approved manufacturers/suppliers should be encouraged to take on jobs related to the installation and maintenance of domestic meters. Meter specifications should be ensured for its appropriateness.

4. MCJ should properly document information on their experiences vis-à-vis meter installation, calibration, recording and performance; consumer reaction to metering; revenue realisation and; resource conservation etc. This information shall be handy for future implementation on a larger scale.

5. Modifications need to be made in the existing system of water bill generation and collection, which is based on flat tariff structure. Therefore MCJ should also train the staff both about the advantages of metering as well as the metering and billing procedures.

6. There is a need for parallely creating consumer awareness and their willingness to pay should be assessed, on the city level, on the benefits of metering for a successful implementation of the project. This should serve to address the likely misconceptions on metering like the life of the meter, its accuracy and apprehensions regarding inflated bills, while linking it to correct installation practices (like the method of installation and provision of strainer and NRV).

7. Implementation on a larger scale should be done in phases and wards/zones for the next phase of implementation should be identified alongside.

8. Possible arrangements for the installation and cost of meter should be worked out in advance before scaling up on this activity. Different options that could be provided to a consumer include:

   a. **Option 1:** Consumer gets the meter installed from a select list of manufacturers approved by MCJ.

   b. **Option 2:** MCJ bears the responsibility to install a domestic meter at the consumer end. The consumer may be given the option to either pay the entire amount (towards meter cost and its installation) immediately or as instalments spread over a period of 12-18 months which may be included as meter rental.

These options have to be worked upon judiciously as Option 1 may have fewer takers on account of poor willingness or the costs involved. The success of Option 2, on the other hand, depends on the collection efficiency of the system.

***Medium term***

1. Successful implementation on a pilot scale needs to be followed by the installation of meters in other areas with similar characteristics in terms of consumer awareness, revenue realisation and water supply. It is recommended that the entire billing system should be modernised within 3 years of implementation (discussed in the section on Institutional reforms).

2. It has been observed that more than one household is connected on a single connection. MCJ should discourage such a practice and should have an updated database of consumers by the end of 3rd year of implementation.

***Long term***

In the long term all connections (domestic, consumer and industrial) should be metered and linked to a modern billing system.

### *5.1.1 Obstacles in implementation*

The process of metering is likely to face a lot of resistance from different stakeholders like consumers, politicians, decision makers, and staff etc. due to the following reasons:

1. Costs involved in the process.
2. Quality of service currently provided.
3. Apprehension of an increase in water bill.
4. Increased workload for the billing staff, especially the collection staff.
5. Political sensitivity of the issue.
6. Limited consumer awareness on the need for water conservation etc.

It is therefore essential that within the first 2 years of implementation, a consensus on the subject be built amongst all stakeholders. This shall require showcasing the advantages of a metering system and disseminating the success story, particularly to the consumers. Implementation using the PDCA approach shall be handy in countering the above obstacles.

### *5.1.2 Institutions and stakeholders to be involved*

1. Consumer awareness groups
2. Resident welfare associations
3. Water meter manufacturers/suppliers
4. Bulk consumers
5. Funding agencies
6. Staff of MCJ and PHED
7. Media
8. Elected representatives and politicians
9. Research and engineering institutes

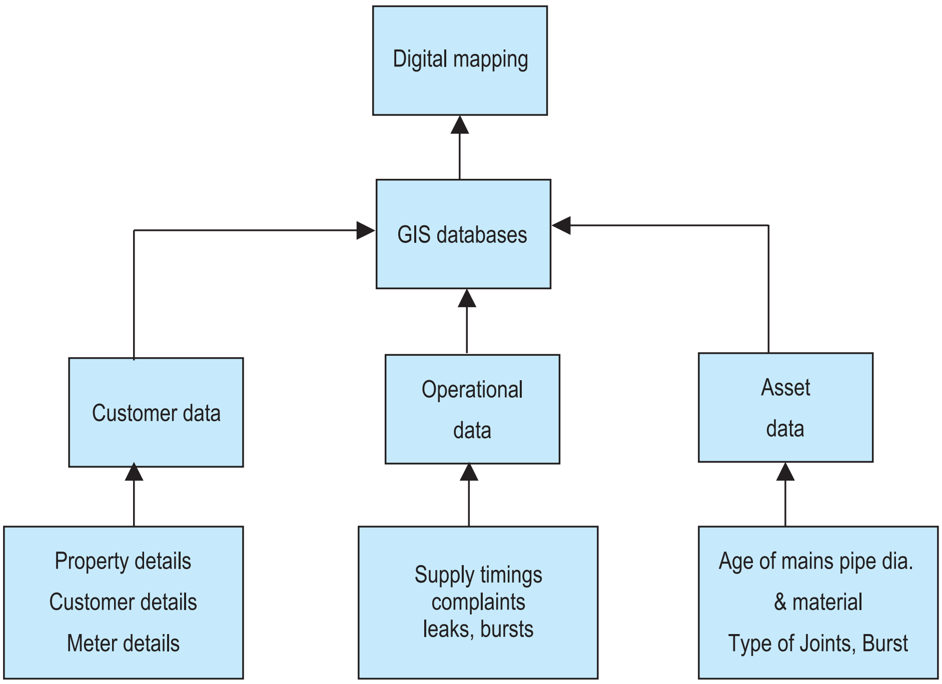
## 5.2 Development of database management system using GIS

One of critical bottlenecks in implementation of any water demand management strategy is the lack of updated data on various aspects of water supply. Database generation is an important step to account and analyze the performance of MCJ and also equip it with necessary information required for decision making at all levels. Thus it is imperative to couple WDM strategies such as metering with an effective data acquisition, compilation and processing system to use it as an aid for decision-making.

A database management system would essentially consist of formats and tools for collection and compilation of data. It is thus proposed to set up a spatial data base system wherein all records related to water operations under the MCJ are maintained on a GIS platform. Database management can be categorized into collection as alphanumeric and maps format.

### *5.2.1 Data requirements*

The utility needs to record data basically on three parameters: Consumer data, operational data and asset data. A framework for a GIS based data base system is given in Figure 5.1 below:




**Source:** M N Thippeswamy, GWSSB Training programme, August 2004

**Figure 5.1** Framework for GIS database system

The above framework clearly identifies the kinds of datasets required by MCJ to monitor its performance and take measures towards improvement of service delivery. Although some data sets are available with MCJ, but current information is not sufficient for an efficient and effective management of resources. It is thus recommended that a robust database should be maintained on both the supply side as well as the consumer end. Given below is an indicative list of the datasets to be collected.

### *5.2.2 Asset data*

1. Source details: Number, capacity (yield), type etc.
2. Treatment plant details: capacity, units, pumping details etc.
3. Transmission mains:
    a. Gravity mains: Length, MOC, Diameter etc.
    b. Pumping mains: Length, MOC, Diameter etc.
4. Distribution network: Length, Diameter, MOC etc.
5. Number and capacity of reservoirs like OHTs, GSR.

6. Pumping stations: No. of pumps, capacity, rated capacity, efficiency etc.
7. Appurtances: Details of joints, valves etc.

### *5.2.3 Operational data*

1. Flow records:
   a. Details of flow meters: type, specifications etc.
   b. Flow records: Instantaneous and totalised flow records to be maintained as a spreadsheet.
2. Supply timings
3. Complaints
4. Leaks/Bursts
5. Pressure records

On the consumer end, database should include:

1. Number of zones in the city
2. Name and number of each ward
3. Population in each ward
4. Number of legal and illegal connections
5. Per capita consumption based on domestic meter reading
6. Customer Details: Details of domestic, commercial and industrial consumers, type and size of connections, metering records etc
7. Billing records
8. Property details

Although these databases are generated in an alphanumeric format, these can also form an attribute in GIS database by linking it with maps and locations.

### *5.2.4 Map format*

Conventionally, data on the pipeline networks were collected and stored in paper format. In most of the cases these information are just sketches rather than a proper network layout maps. Such an approach of network data management and storage is not only labour intensive and prone to errors but also less useful for efficient utilisation and management. Further more with frequent developments in the network, updation of such paper-based maps is a laborious assignment. Unlike paper maps, digital maps can link database features to supporting documents making the updating process relatively simple, faster and accurate. Moreover, paper maps degrade over the years whereas digital maps can be stored and easily upgraded from time to time. Digital maps also ensure that all knowledge is not lost in the case of changes in guard/responsibility and enable linking of information with other tools for management and analysis.

Once such a comprehensive and accurate information base is created in GIS platform, it can be easily shared/transferred for use by different departments (based on the scope of their work) and such an approach of centralized data management system makes the process of updation and management of information efficient and easy.

The major bottleneck in implementation of GIS based water supply network information for Jabalpur city is the non-availability of a comprehensive base data for water distribution network. The only available information on water distribution network for Jabalpur city is a map developed in Auto CAD that contains limited information on water distribution network for the city. The lack of detailed information on network distribution seems to be a constraint for efficient management of resources.

An integrated comprehensive water supply network database is important to get a holistic idea of the entire network distribution and once supported by other ancillary information (like road network, locations and landmark etc.), such a knowledge base provides an enormous support for resource management and planning. As part of this project's activities, and at the beginning of the process of a development of a comprehensive information and management system, existing ward wise Auto CAD maps have been converted into a GIS database (ArcGIS, ESRI) and integrated to generate a city level holistic information base. The greatest advantage of such a system is that the data and information are geographically referenced that supports accurate measurement based on maps and the facility of location based search.

In addition to the water supply network information, the database also contains other supplementary information important for efficient management of water supply resources. The data comprises of ward maps, major water distribution network, tanks, road network and railways etc. for Jabalpur city in GIS format. Figure 5.2 shows a part of Jabalpur generated in GIS environment.


**Figure 5.2** Part of Jabalpur generated in GIS environment

However, it is worth noting that, such a database is developed based on secondary information and relatively low level of accuracy are always prone to certain level of inaccuracy, specially in the case of pipeline network distribution. In this regard it is highly recommended that accuracy assessment of such databases needs to done based on stakeholder consultation and selective ground survey. Such a database can be considered as a baseline and further refinement, updation and development can be done based on information to make it more accurate, updated and comprehensive. Details of development of database in Bangalore Water Supply and Sewerage Board is attached as Annexure 5.3 and is a good reference.

Table 5.3 provides the details of various GIS themes generated under the current study and the information associated with these themes. Soft copies of the GIS maps prepared by TERI are being submitted with this report. Annexure 5.1c is the proposed activity schedule for implementation of this strategy.

**Table 5.3** Details of various GIS themes

| Sl. No | Layers | Format | Attributes |
|---|---|---|---|
| 1 | Ward boundary | Polygon | Ward boundary |
| | Ward Info | Point | Wards wise information on population, no of water connections, metered/non metered connections, illegal connections |
| 2 | Pipelines | Line | Details of water supply network containing information on various pipeline size |
| 3 | Water Tank | Point | Type like OHT, sump well or tanks |
| 4 | Valve location | Point | Location of valves |
| 5 | Leakage location | Line | Location of network leakage |
| 6 | Pump House location | Line | Location of pump houses |
| 7 | Water Body | Lines | Location of rivers, streams and water bodies in Jabalpur |
| 8 | Road | Line | Road network information |
| 9 | Railway | Line | Rail network information |
| 10 | Landmark | Point | Type of landmarks like railway station, post office, hospital and important locations |
| 11 | Builtup area | Line | Built-up area |
| 12 | Green | Poly line | Play ground |
| 13 | Pump House | Point | Location |
| 14 | Cant. boundary | Line | Cantonment boundary |

## Implementation Plan

### *Short term*

1. The existing maps were in Auto CAD; TERI has already converted them into the GIS format. However, a primary survey needs to be conducted to update the existing information (more accuracy is needed) using differential GPS (Global Positioning System) for an increased precision and accuracy. Attributes that need updating include valve locations, pipe characteristics, location of leakages etc.

2. A separate department should be formed in the MCJ to handle such databases and to carry out updation of data on a regular basis.

Unless MCJ takes concrete steps to update the GIS database on a regular basis, the very purpose of the exercise shall be defeated and the database shall become outdated. Any addition or alteration in the existing water supply infrastructure should be communicated to the cell responsible for maintaining this database. Besides, information on adjoining roads, railways, important buildings, other pipelines etc. also needs to be updated regularly on this database. It is also recommended that the database be updated on a quarterly basis.

***Medium term***

Details of all attributes at the ward level like revenue generated in each ward, concerned staff and their contact details, staff strength, number of legal/ illegal connections, number of leakages reported/ unreported and other administrative details should be included. This information shall be very handy to assess the performance of each ward on a regular basis and benchmarking performance. These details should be updated regularly every financial year.

***Long term***

This database should be integrated with a consumer MIS wherein information about consumption, feedback etc is also recorded and could be analysed.

#### *5.2.5 Obstacles in implementation*

- Initial updation of maps can be very costly and laborious as primary survey needs to be carried out.
- Limited capacity within the MCJ.
- High installation cost.
- Administrative hindrances for new cell formation.

***Institutions and stakeholders to be involved***

- MCJ /PIA cell and PMU (UWSEIP)
- Research and Engineering institutes
- Private GIS consultants
- Funding agencies

### 5.3 Water audit and balancing

Water audit and balancing provides a comprehensive appraisal of the availability, distribution, utilization and the extent of losses in the system. Such an assessment is extremely useful in resource assessment, policy formulation and decision-making particularly on future investments in infrastructure. A water audit is a thorough examination of water systems records and field control equipments and helps in accounting for all the water distributed through a water system. In simple terms, auditing the water usage implies doing a mass balance study wherein the inputs to a system are compared with the aggregate of consumption and outputs, to assess the difference that is the loss or unaccounted water.

Water audit exercises have been carried for urban water supply systems in the cities of Bangalore, Jaipur, Delhi and Hyderabad to assess the extent of water and revenue losses in the supply system and to identify areas where improvements need to be made.

In context of Jabalpur there is need that significance of such an exercise in water management is understood well and all missing information be generated to facilitate water auditing and balancing. There is also a need to procure necessary infrastructure and develop capacity to undertake water audits on a regular basis.

Areas recommended for pilot study are:

1. Brahman Mohalla in the Medical area, with about 300 households that can be considered for the study. The area is discrete that does not have tube well supplement and is supplied with stand posts.
2. Satyanand vihar, which has 70-80 households.

### *5.3.1 Implementation plan*

***Short term***

1. Since a lot of bulk meters are non-functional hence at first the old meters should be repaired/ replaced and new meters be installed at the locations suggested in table 5.1. Water audit should then be undertaken in pilot areas to assess extent of water losses in the network. These pilot areas should ideally form a closed and discrete loop and should be representative of the condition of the water supply network in different stretches of the city vis-à-vis its age and health.
2. The audit exercise should preferably be carried out in those networks (transmission and distribution) for which accurate information is available on parameters like layout, size, material of construction, branching of the distribution network etc. In cases where such information is not available or accuracy of information is questionable, water audit exercise should be used as an opportunity to update maps of the distribution network.
3. During the pilot exercise, auditing should be carried out at regular intervals to obtain multiple sets of information, preferably for two seasons, so as to have a better understanding of the behaviour of system under different demand scenarios.
4. MCJ should select a team and build their capacity to undertake auditing and balancing in pilot areas. This team should then train relevant staff in other zones on how to carry water audits and translate the lessons into better water management practices.
5. MCJ should consider procuring more numbers of portable meters for carrying out water audit for riders, tube well supplies etc. Capacities of the staff need to be built on undertaking such an exercise and on operation, calibration and upkeep of such infrastructure.
6. An auditing of the performance of Ranjhi, Lalpur and Bhongadwar treatment plant should also be carried out to gauge the extent of water lost during treatment and take possible measures upstream of treatment and within the treatment process.
7. Water auditing should become a regular feature and hence a part of the planning phase for all existing, upcoming and up gradation projects. Planning phase should consider making provisions, as and where ever possible, for locations where flow metering could be done. This would facilitate water audits and balancing on such networks.
8. The data set generated from water balancing should be used to calculate ILI for pilot areas and suggest measures to be taken to reduce the index value.
9. There is also a need to undertake auditing of water usage at the consumer end to build a case for conservation at the consumer end. This exercise should be initiated at a pilot scale to make the consumers more aware about efficient practices of water usage.

***Medium term***

1. A comprehensive water audit programme should be undertaken in a larger area and should also cover water usage patterns at the consumer end. The ultimate aim of this phase of the exercise should be to reduce leakages and wasteful use of water; and better revenue realisation.

This exercise shall also help in:

- Reviewing the existing distribution network to identify stretches where pipelines need to be replaced.
- Checking and calibrating meters.
- Analysis of water supplied for free.
- Leakage control.

- Equitable distribution of supplies.
- Share of each source in supplied water.

2. Once bulk meters are installed in OHTs and GSRs and respective households are metered, auditing should be carried out at these locations.
3. The data set generated should be used to calculate ILI on a city level and frame policy for repair and replacement of the pipe infrastructure.

***Long term***

Once metering is done across the city, water balancing could be done on a zonal level regularly so as to continuously monitor the quality of service delivery and analyse possible impacts on any proposed changes in the supply scheme.

#### *5.3.2 Obstacles in implementation*

The process of water auditing and balancing is likely to face many challenges on account of:

1. Costs involved for procuring water flow meters.
2. Inadequate information on layout of pipelines.
3. Identification of pilot zones and preparation of discrete areas for water auditing.
4. Extensive network modelling exercise must be undertaken and MCJ should move towards implementation of SCADA system for management of the distribution network.
5. Manpower required for carrying such a comprehensive exercise and its capacity.

#### *5.3.3 Institutions and stakeholders to be involved*

1. Consumer awareness groups.
2. Resident welfare associations.
3. Staff of MCJ and PHED.
4. Research and engineering institutes.

### 5.4 Sectorisation/District metered areas

Jabalpur is currently divided into 8 zones and 60 wards. The existing demarcation of wards and zones is more from an administrative perspective and does not consider effective water management (based on the hydraulics) as one of the criterion for delineation. Although Jabalpur does not have scarcity of water resources however efficient supply system is the need of the hour. It is recommended that the entire city be divided into small discrete units called District Metered Areas (DMAs), for an effective management of the water supplies. This assists in a better monitoring of the water supplied vis a vis the quantity supplied (total and lpcd); water consumed (total and lpcd); leakages in the system before and after the property line/consumer meter. Such sectorisation on hydraulic principles also assists in:

- A uniform and rational allocation of resources to each unit (water, finance, manpower, subsidies etc); effective and systematic maintenance and, better revenue realization etc.
- Comprehensive rehabilitation of the water supply facilities in the DMAs.
- Implementation of pilot projects in a small area and showcasing best practices.
- Establishing costs of introduction of DMAs, metering program and network.

### *5.4.1 Implementation plan*

***Short term***

1. In the short term it is recommended that a pilot project be commissioned for establishing a DMA in a relatively smaller area. The lessons learnt from the pilot scale implementation should then be used to develop a plan for sectorisation of the entire city. The pilot implementation can be conducted in areas such as Brahman mohalla and Satyanand Vihar.
2. As Jabalpur is supplied by about 23 reservoirs DMAs can be established in one of these areas. As water is also supplied from tube wells, monitoring and accounting of flow from tube wells is also required.
3. In a short term, it is recommended to identify DMAs in some of the progressive zones of Jabalpur. These locations should preferably also be representative of the different operational conditions in the city in terms of age of pipelines, topography of the area, duration of supplies etc.
4. As most wards in the city receive water from multiple sources from WTP and tube wells, the city should be divided into various sectors with 20000-30000 connections at a time, based on the distribution network and supply scheme. Discreetness of the zone should be preserved, at least by controlling the valves, if not by a separate set of pipes.
5. Identify feeding points for each DMA and install bulk meters at all feeding points.
6. Check the functionality and accessibility of all valves, pressure gauges in the DMA.
7. Remove interconnections with other supply areas as much as possible. Isolate the selected DMAs and test whether full isolation has been achieved.
8. A network analysis of the water flows should also be undertaken in the identified DMA to comprehend behaviour of the system. This shall be useful for implementation of any changes in the network ranging from leakage repairs to augmentation to metering to planned maintenance etc.
9. Execute a minimum night flow test as an initial indication of the level of physical leakage and to determine the need for system rehabilitation.
10. Test run the possibility of a round the clock water supply to the identified DMA and analyse performance vis a vis total leakage, consumption patterns and water losses.

***Medium term***

1. An internationally accepted norm is to have a zone with 2000 to 4000 properties. However, it is advisable that DMAs (in the second phase of implementation) be identified in the city in line with the existing administrative zoning, and layout of the distribution mains and valves.
2. Water supply to each zone should be properly controlled by valves and a boundary of each zone should be defined and mapped in the GIS database.

***Long term***

1. In the long term, the entire Jabalpur city should be divided into DMAs and each boundary should be mapped into a GIS environment.
2. All zones should be monitored and flow from each zone should be documented properly. Such documentation helps in network modelling and in accounting of flow in each pipe across the network.
3. Modern techniques such as pressure management night flow analysis etc should be used for reducing losses.

### *5.4.2 Obstacles in implementation*

As of now lot of areas in the entire system has been laid out in an unplanned manner on 'as and when/where ever required' basis. The city has also developed in an unplanned way. Therefore, limited information or information of a limited accuracy is available on the system layout, especially of the distribution network. As a result of lack of adequate information and the uncertainties involved, it is difficult to develop DMAs in the city and demonstrate the usefulness of the same. Therefore, a pilot stage implementation is suggested initially.

Limited capacities of the staff and their awareness on usefulness of the concept could be another major obstacle to be addressed before implementation. It would therefore be difficult to justify the cost of such an implementation.

It is desirable that accurate information should be available on network before such an implementation. Therefore for this activity to be undertaken accurate GIS map for the pilot DMA area should be ideally available.

## 5.5 Energy auditing

Water utilities are intensive energy users and continually seek ways to improve their productivity through the effective and judicious use of energy. An effective manner of reducing energy consumption is to conduct an energy audit. An energy audit involves a critical examination of an energy consuming facility. It determines the performance of a facility in terms of energy use and relates its energy consumption to production and compares it with the performance of similar organizations. An energy audit is an imperative first step for any organization interested in implementing an energy management program within their facilities and assists with identifying areas where potential savings can be made. Increasing the energy efficiency will enhance the facility's operations and products in numerous ways:

- It can reduce energy costs: Reducing the energy expenses can help the water utilities to redirect the resulting savings to improve the facility For municipal water utilities especially, the energy cost reduction can help achieve a lower water tariff, increased service connections, and additional operational funds for expansion or improvement of service.
- It can help the utility to improve the quality of its product. For example, improving pump performance in a water utility can ensure the right volume and pressure of water that needs to be supplied.
- It can lead to corollary benefits such as reduced maintenance costs and improved worker safety. It can also help in reducing pollution.

Municipal water utilities in India spend more than 60 percent of their budgets on energy used for water pumping. The CII (Confederation of Indian Industry) estimates that the typical Indian municipal water utility has the potential to improve water pumping system efficiency by 25 per cent. Box 1 highlights the experiences of some of the municipalities post energy auditing.

In Jabalpur, water from the Narmada is collected into an Intake well (at about 187 m distance) and subsequently pumped to the Lalpur WTP, hence expenditure on power consumption is incurred. Such expenditure head therefore provides opportunity for improvement and thereby generate more financial resources for other activities.

### *5.5.1 Implementation Plan*

***Short term***

1. Pumps are operated under throttled conditions most of the pump houses in an attempt to deliver water to all reservoirs, which incurs a huge loss of energy. This can be minimised by installing booster pumps near OHT's to meet required head.

2. At Narmada River pumping station 10 pumps of 225 HP are installed of which four pumps are running and the remaining six pumps are used as stand-by. The operation of the facility installed for this pumping station need to be optimised- mainly the transformer load management.

3. It was observed that at Gaur Pumping Station four pumps are installed of which 2 Nos. of 150 HP and one of 120 HP are in use. For the operating pumping capacity, piping system network need to be reviewed for energy efficiency aspect. The following energy conservation aspects at local/ booster pumping stations need to be looked:

   - Contract demand issues for tariff reduction.
   - Power factor management to avail the rebates in tariff.
   - Transformer load management.
   - Optimising the operating hours of the pumps by eliminating the delivery throttling.
   - Replacement of old pumps.
   - Replacement of slip ring motors with induction motors along with soft starters.

4. Energy audits are specifically required for assessing the pumping efficiency of Ranjhi and Fagua pump houses, supplying treated water to Jabalpur city. As part of pilot project, energy audit can be carried at Ranjhi (Pump House 1) and Fagua pump houses.

5. Replacement of old pumps (Ranjhi PH 1) and proper management of transformers will reduce power consumption.

**Picture 5.3** Fagua Pump House

6. Expenditure on power consumption should be recorded and tracked by installing energy monitoring systems near all pump houses and treatment plants.

7. In a short term, this activity could be out sourced to a consultant. There is a need to simultaneously build the capacities of MCJ staff on energy audit.

***Medium to long term***

1. A team of Mechanical and Electrical engineers should be constituted and trained in PHED/ MCJ to carry out regular energy audits.

2. Energy audits of all pumps and transformers at each treatment plant need to be carried out regularly, at least once in every six months.

**Box 5.1** Experiences post energy auditing in some municipalities

**I. Energy efficiency drive – Karnataka**

In May 2002, the Alliance to Save Energy launched its state-wide municipal water and energy efficiency outreach programme to disseminate the concept of water in the south Indian state of Karnataka. The Alliance entered into a strategic partnership with the KUIDFC (Karnataka Urban Infrastructure Development Finance Corporation). As part of a sustained capacity building process, the Alliance helped establish an EMC (Energy Management Cell)at KUIDFC and trained its engineers in energy efficiency best practices.

In its initial stage of capacity building, the Alliance identified four municipalities of varying sizes and located in different revenue divisions as pilot cities. These cities were Hubli-Dharwad, Mysore, Bellary City and Tiptur-Arasikere. The Alliance, in partnership with TERI,(The Energy Resources Institute) facilitated energy audits of bulk water supply systems and efficiency assessments of street lighting systems in these municipalities. The resulting audit reports indicated a tremendous potential for energy and water savings with limited financial investments and rapid payback periods. The proposed energy savings measures are of two types: no cost and low-cost, and larger capital investments.

The no-cost/low-cost measures have a pay back period of less than a year and involve measures such as surrendering excess contracted electric demand, maintaining a good power factor for electrical equipment, improving water flow distribution, rescheduling pump operations and improving pumping efficiencies. These simple measures account for about 15-20% of the energy and financial savings. Measures requiring large capital include replacing inadequate pipelines, replacing impellers, installing energy efficient motors and replacing old inefficient pumps with energy efficient pumps that are better integrated to the system.

The implemented energy savings measures in thee audited bulk water supply systems of the four pilot municipalities will result in an energy savings of close to 8.2 million kilowatt hours annually, thus reducing 8200 metric tons of CO2.

The simultaneous reductions in municipal water waste, through more effective supply and distribution, will allow the municipalities to deliver water to more homes. Approximately 1.3 million people can be served with water by the energy saved. Alternatively the energy saved can be supplied to 71,000 additional homes.

**II. Vishakhapatnam Municipal Corporation (VMC)**

VMC has implemented different energy audit recommendations made by TERI. Measures range from no-cost/low cost to high cost and include retrofitting of pumps and motors, optimum utilization of contracted demand, segregation of low tension and high tension, and trimming of impellers. As a result of these measures, VMC is now accruing an annual energy savings of 1.4 million kWh amounting to an annual financial savings of approximately US$ 60,400 with an investment of only US $24,500. This has reduced VMC's annual energy bill for pumping water by about 5.4 percent, and has also led to a reduction of about 2,400 metric tonnes of $CO_2$ emissions. The simultaneous reductions in municipal water waste, through more effective supply and distribution, will now allow the municipality to deliver water to more homes (www.ase.org).

## 5.6 Active and passive leakage control

Leakage management refers to the identification and repair of leaks (visible and underground) in the water supply system and reducing water losses to an acceptable level. Leakage management is a continuous process and needs to be undertaken continuously rather than as a one off initiative.

Site visits carried out while assessing the supply system reveals that a considerable amount of water is lost during transmission and distribution of water. Further, as of now there is no estimate of leakages beyond the property line and such leakages are not even considered as losses.

Heavy Leakages are observed in the transmission line from Khandari Dam (Picture 5.5). The pipeline bifurcation from Bhongadwar to MES had significant leakage as shown in Picture 5.6. It is thus evident the distribution network is leaking all over.

**Picture 5.4** Leak detection equipments

Although there was not much treatment losses occurring in the treatment plant, but during the visit leakage was observed at pipeline near 42 MLD plant area at Lalpur WTP. As informed by the MCJ officials there are about 8-10 leaks reported per month in the rising mains. There are frequent leakages that occur in city. These leakages occur mainly during the laying/repairing of telephone lines and repeated wear and tear of underground pipes due to traffic movements. Such leakages need to be traced and rectified. No system exists to document properly all information on leakages like the number of complaints received, their type (major or minor), and the time taken to address them etc.

**Picture 5.5** Leakage at pipe from Khandari Dam to Bhongadwar

Leakage management refers to monitoring the flows into supply areas in order to measure leakage and prioritize leak detection activities. Leakage management is usually one of the most effective methods of reducing losses in the Indian context owing to high level of losses in the transmission and distribution. Annex 5.1d highlights the proposed activity schedule for implementation of this strategy.

**Picture 5.6** Leakage near Bhongadwar MES bifurcation

**Picture 5.7** Valve leaking near Bhongadwar

Currently no means are adopted to detect small leakages from underground pipes. This should be carried out to evaluate the losses accurately for better management.

### *5.6.1 Implementation plan*

***Short term***

1. As a first step, MCJ needs to have a strong policy towards active leakage control. This has to be followed by identifying a dedicated team for leakage detection and control. Leakage at the pipeline from Lalpur WTP should be repaired. Pipeline from Khandari dam need to be replaced and the leakages curbed.

2. To begin with all visible leakages occurring from transmission pipes, valves; and pumps should be repaired immediately. It is also necessary to check leakages (if any) occurring from the Pariyat dam.

3. It was also observed that the water supply taps are not regulated with caps. Such taps should be identified and caps be installed on the taps.

4. As a part of pilot study, active leak detection must be carried out in pilot study areas such as Brahman & Satyanand Vihar for repair of all visible leakages (including underground leakages) from transmission lines. This will help in assessing amount of leaks, time taken to detect leaks and repair it etc. Such study will also help in preparing leak detection management for entire city. This is a good approach to identify stretches that are prone to ingress of sewage or soil because of leakage in the pipeline and a negative pressure.

5. Capacities of the staff have to be built on the use of simple techniques, as discussed in Box 2, like using acoustic rods etc to identify leakages, especially in underground networks. In a short term, MCJ could consider out sourcing a comprehensive exercise of leakage detection and repair.

6. Changes in the quality of treated water during its conveyance in distribution mains should be assessed and analysed. This is a good approach to identify stretches that are prone to ingress of sewage or soil because of leakage in the pipeline and a negative pressure.

7. There is also a need to enclose all existing small pipes in a small conduit to avoid any chances of likely pilferage and water thefts.

8. While active leakage control is recommended, there is also a parallel need to revamp the existing system of passive leakage control wherein action is taken once leaks are reported. The system should be tuned to:

   - Systematically record complaints on bursts and leakages in a proper format (date, time, type, reason, previous history etc) and maintain a history of the same. Information on all types of leakages, their location, age of pipes and replacement of pipes should also be recorded in the GIS database.

   - Reduce time taken for the communication and location of leakage. This can be done by creating adequate consumer awareness on the subject, as consumers are likely to be the first ones to observe leakages. Consumers should be encouraged to report telephonically and the information should be obtained in a comprehensive manner seeking all relevant details. Accurate and timely communication is the key to efficient action. This can help in fixing the leakage problems without much loss in resource and avoiding further damage to pipe infrastructure.

   - MCJ could consider out sourcing this exercise of receiving complaints using the services of a private call centre.

**Box 5.2** Methods for identification of leaks

**(a) Walking**

Walking over the mains looking for signs of accumulated water, damp soil, etc. indicating leakage of water.

**(b) Sounding**

Sounding is the cheapest and an effective method of detecting leaks in a medium sized water supply system.

Sounding could be categorized into two types: Direct & Indirect

- Direct sounding is made either on the main or fittings on the main such as sluice or air valves, fire hydrants stop taps or any other suitable fittings.
- Indirect sounding consists of sounding made on the ground surface directly above the mains for locating point of maximum sound intensity. This method is a good supplement for confirming location of leak noise identified through direct sounding. Water escaping from a pressurized pipe emits a sound similar to the sound that can be heard when a seashell is held up to the ear.

Other sounding techniques used include listening sticks, ground microphone and leak noise co-relator.

***Medium term***

In the medium term MCJ should consider procuring leak detection equipment. Further adequate training on leak detection and control should be given to the leak detection cell on the use of the equipment. Proper sounding techniques are needed to identify underground leakages. It is suggested that simple amplified sounding rods may be procured in the medium term to detect leakages. In addition there is a need to build capacities (of the zonal level staff, especially line men) on their use.

## 5.7 Asset management programme

Asset management program involves developing a time bound plan for retrofitting and replacement of existing infrastructure in a manner, which ensures that the system keeps functioning at optimum efficiency. Usually in a stressed system with limited financial resources, as in case of MCJ, there is no focus on a proper upkeep of the system and the infrastructure out lives its age. Infrastructure replacement is the last measure that a utility takes because of the expenses involved. It is therefore important that any replacement is properly coordinated to avoid wastage of limited resources.

To move towards the long term objective of providing 24-hour water supply to the city in a sustainable manner the existing infrastructure in the city needs to be replaced or rehabilitated in a phased manner. Most of the water supply network to Jabalpur is old and requires rehabilitation to service the entire population. Infrastructure replacement may be broadly divided into 3 main categories.

1. Water treatment plants/pumping stations
2. Transmission network
3. Distribution network
4. Appertances (valves, expansion joints etc)

### *5.7.1 Implementation plan*

***Short term***

1. Field surveys reveal that pump house at Gaur, Fagua and that at Ranjhi (Pump house –1) needs renovation.
2. There is also a need to improve the housekeeping practices in Ranjhi WTP and Bhongadwar treatment plant.

3. There is need to evaluate the conditions of electrical units and wirings in the pump houses and have safer installations.

4. Valve on mains from Bhongadwar should be repaired/replaced. A survey of all valves in the network is recommended to identify leaking and faulty valves. The valves may then be repaired or replaced accordingly. Besides preventing leaks, repair of valves will also help in better management of pressure.

5. Pipes from Khandari Dam to Bhongadwar WTP should be replaced, as leaks were prevalent in the pipeline and the age of pipeline is more than 100 years.

6. There was a severe leakage from 36-inch pipeline, which is carrying water from Ranjhi Pump House No. 1. This pipeline should be replaced with a new pipeline.

7. Similarly common collection sump for Fagua and Pariyat and the notch from Pariyat to the Ordinance Factory, Khamariya needs renovation.

8. The Kulli hill tank and the Belbag tank need to be renovated. Leakage and seepage from OHTs should also be assessed and repair works should be undertaken immediately.

9. It is thus proposed that, subsequent to the mapping of the entire network in GIS, a detailed project on replacement of the existing network may be undertaken.

10. It is also necessary that inventorisation of the entire infrastructure be carried out and recorded properly. This shall help in a better assessment of the health of infrastructure and resources needed for its maintenance. Budgetary allocation for such activities can be made accordingly. Depreciation of the assets can also be gauged and reflected in the financial statement.

***Medium term***

1. Once a detailed survey of existing pipelines and its leak detection is completed and mapped in GIS platform, it is necessary to prioritise leakage repair and pipe replacement program.

2. Replacement of old pipelines in the distribution network should be carried out in accordance with a worked out plan. Pipes, which are more than 50 years of old, should be given more attention and their physical condition should be evaluated.

3. Proper concealment and protection of existing and proposed bulk meters, pressure gauges, air release valves and other valves should be ensured.

4. Replacement/repair of pumps should be evaluated after each energy auditing exercise. In the medium term the infrastructure replacement programme should be designed and implemented based on the outcomes of the leak detection programme and the DPR for infrastructure replacement.

5. It has been observed that infiltration of sewage from septic tanks and pipelines affects the quality of water in supply lines. It therefore becomes essential that besides maintaining the health of water supply pipeline infrastructure, a formal system should be constituted to regularly inspect the infrastructure available for sewage collection (and its treatment). This shall check any possible contamination of potable water supplies.

***Long term***

1. Relaying of pipelines as required by the new proposed DMAs should be carried out. This will eventually lead to a well-defined water supply network, which shall form a hydraulic zone rather than being delineated on administrative basis.

2. Direct Connection to Households from Treatment plant (called riders) should be removed phase wise and OHTs should be constructed which will help in storing, monitoring and maintaining pressure to consumers.
3. In the long term it is envisaged that the city will be sectorized into hydraulically discrete zones and water supply shall be round the clock. The transmission and distribution mains, OHT etc. may need to be redesigned according to the new water supply regime.

#### *5.7.2 Obstacles in implementation*

1. Capital requirement for such replacements may be huge and will be subjected to resistance.
2. Efficient management is required for analysing and prioritising the replacement program, which required skilled managers and engineers.

## 5.8 Planned maintenance

As analyzed during the financial assessment of MCJ, only a miniscule portion of the total expenditure goes towards maintenance. Maintenance is based on 'as and when required' approach rather than a committed attitude where upkeep is systematic, planned and regular. The result is that system efficiency and service delivery are affected because it operates with infrastructure that is poorly maintained and in some cases outlived, as reflected by the leaking and non-functional infrastructure. There is a need to realise the significance of planned maintenance, especially in over stressed system which caters to a big population, so as to increase the overall equipment/infrastructure availability and reliability.

It is necessary that regular monitoring of system health be undertaken to cover all infrastructure i.e. pumps, water treatment units, pipes, valves, meters and storage units etc. MCJ should have a system for planned maintenance with adequate resources allocated to the activity and this should strictly be adhered to. The history of the health of the infrastructure should be duly maintained as this can facilitate decision making on maintenance and replacement.

#### *5.8.1 Implementation plan*

***Short term***

1. In the short term, there is a need to collate information on the age of the infrastructure. In the first stage, assessment of all valves should be carried out as leakage from the valves is most visible and reflects very poorly on the commitment levels of the service provider. Besides the valves, immediate attention is required for all pumping infrastructure as also pointed out during the discussion on energy auditing.
2. It is important to prioritise expenditure on maintenance in the annual budget. Based on existing conditions and severity of deterioration / depreciation of different units, funds should be allocated for maintenance.
3. Identify dedicated staff for the activity and launch training and campaign within MCJ on the subject. There is also a need to promote the following steps to build the diagnostic skills of the staff of MCJ:
   a. Initial cleaning
   b. Counter measures for the cause and effect of dirt and dust
   c. Cleaning and lubricating standards
   d. General inspection

   e. Autonomous inspection
   f. Organisation and tidiness
2. In the short term, MCJ could also consider involving an outside agency to prepare a schedule for planned maintenance of its different operations. For this some of the representative facilities and infrastructure could be selected.

***Medium to long term***

In the medium term, staff capacities should be built on organized approaches for planned maintenance aiming at zero breakdowns.

#### *5.8.2 Obstacles in implementation*

In absence of any policy and vision on the need for regular maintenance, it would be difficult to take adequate measures. Further, lack of financial resources may also create hindrance for the proposed implementation.

## 5.9 Alternative supply means

Traditionally water supply in urban areas has been through piped systems with either a household connection or public stand post at the user end. However given the resource constraints and technical barriers it may not be possible to cover the entire population with piped water supply. The current approach of providing tankers in areas not served by PWSS (piped water supply scheme) is also inefficient and raises concerns related to water quality and poor service delivery levels.

Significant quantity of water is supplied through tankers (67 tankers) in Jabalpur but there is no quantification of the amount of water withdrawn from the filling points, the amount of water finally reaching the users and per capita water supplied.

It is thus recommended that in addition to these traditional supply means MCJ should also explore the possibilities of alternative service delivery mechanisms. Some of the approaches, which may be taken up, include:

– Water kiosks
– Decentralised community managed small piped networks
– Group connections as a replacement for Public stand posts
– Rainwater harvesting

There is also a need to monitor and improve the existing tanker supplies aimed at ensuring adequate water quality.

Field observations point that huge quantity of water is lost in the process of filling and transporting water through tankers. Another critical issue is the quality of water supplied through these tankers. No regular cleaning schedule is maintained for these tankers and there is no check whatsoever on the quality of water supplied. Similar observations were made for supplies from the standposts.

### 5.9.1 Implementation Plan

***Short term***

In a short term, the utility should adopt a two-pronged approach wherein the quality of service through tankers is improved. Some of the simplest measures for improvement of supply from tankers may include the following:

1. Tanker filling points need to be modernised to avoid wastages during filling.
2. Improvement in the condition of tankers so as to avoid spilling and leakage. Usually a high leakage is in form spills because of poor lid cover. There is need to make changes in the existing design and for this the milk tanker design, which maintains minimum leakage and maximum hygiene could be referred to.
3. Regular cleaning schedule for tankers.
4. Inspection schedule for ensuring adequate residual chlorine in the tankers.
5. Metering of water supplied through tankers.
6. Supplies based on stand posts should be gradually replaced by household piped water supply system. A detailed plan for providing coverage to the entire city may be developed by the municipal corporation.

It is also recommended that MCJ should take proactive measures towards rainwater harvesting. In a short term, MCJ should undertake rooftop rainwater harvesting in select OHTs, its administrative establishments and government colonies. This shall be useful to demonstrate implementation of rainwater harvesting and show case MCJ's commitment towards water conservation. Harvested rainwater could be used for recharging the groundwater or gardening or consumption by the livestock. Possibilities of reuse of wastewater, post recycling, should also be explored.

***Stakeholders***

In a community-based project forging the right partnerships holds the key to success of the initiative. It is imperative to involve all stakeholders for any such project right from the inception stage. It is further recommended that NGOs be involved for implementation of such project with the municipal corporation playing a facilitation and advisory role.

## 5.10 Water conservation at consumer end

One of the most neglected aspects of Water Demand Management in the Indian context is water conservation at consumer end. Large inequalities in water supply and abysmally low tariffs have led to a situation wherein there is a big difference in the way water is used in different households.

**Box 5.3** Water conservation programmes at the consumer end

The city of Toronto, for example, has been actively pushing demand-side management activities. The city has invested in programmes such as ultra flow flush toilet incentives, industrial waster capacity buyback etc with the goal of reducing peak water demand by 15 per cent.

In December 1989, water-saving kits were delivered to about 10,000 Tampa homes (Florida, United States of America). Each kit included two toilet tank dams, two low-flow showerheads, two lavatory faucet aerators, some Teflon tapes to seal connections, a pamphlet on finding and fixing leaks with a general "water-saving tips" card, an installation instruction folder, a window display card and leak detection dye tablets.

Additional efforts in Tampa include school water conservation poster and limerick contests, an expanded retrofit programme, toilet replacement incentive projects including a rebate programme, implementation of water checkups for large residential water users and enhanced in-school curriculum-based education.

### *5.10.1 Common water-saving technologies*

Several technologies are available to save water and include:

- *Ultralow flow toilets* consume as little as 1/5th to 1/7th of what traditional toilets consume.
- *Toilet dams* or other *Water displacement* devices block part of the tank so that less water is required to fill the toilet following each flush. Some problems may occur with the need to double flush but water savings from these devices are estimated at more than 10 percent.
- *Xeriscaping* involves planting native species that are able to survive under local rain and climate conditions can save large amounts of water. Even though the water consumed for gardening activities in these cities may be very less, there is a need to look at such water consumption. This is all the more important as the Government maintains most of public gardens.
- As a more aggressive strategy, a municipality can enact standards for water-using appliances, at least for upcoming localities with new construction. In the medium term, along with the construction of sewage treatment facility, the Municipal Corporation should also consider exploring opportunities for reuse of treated wastewater.

The cost effectiveness of many of these methods and technologies in practice, however, requires different pricing of water to consumers so as to convey the true cost of the water supplied. In addition to proper pricing, other factors that determine the applicability of certain demand-side measures to water utilities include the market penetration of water-using appliances, the types of industries linked to the system, and the technologies available for the domestic market.

### *5.10.2 Obstacles in implementation*

The existing tariff structure does not encourage the consumers to save water and hence enforcing or imbibing conservation at the consumer end.

### *5.10.3 Stakeholders to be involved*

NGOs, RWAs, Architects and Builders, Bulk consumers and Commercial consumers, Media etc.

## 5.11 Pressure management

Pressure in the supply lines is often used as one of the performance indicators to assess the quality of service provided by any water utility. A water supply system is generally designed to operate at pressures, which lead to minimum head loss while also ensuring adequate pressure to the consumers located at the tail end of the network or on levels above the ground floor. In contrast to utilities in many other countries, water supply in the Indian cities generally faces problems related to supplies at low water pressure. Consumers in most of the cities complain of low water pressure and resort to the use of online booster pumps.

Intermittent supplies coupled with the above-mentioned problems result in a network wherein it is virtually impossible to control pressure and run the system at designed pressure. Frequent filling and emptying of the system also leads to hammering effects, which cause leakages/bursts and hence seriously hamper the life of the system.

**Picture 5.8** Pressure gauge at Bhongadwar pump house

The undulating topography in some of the areas in Jabalpur results in very high pressure at certain points and low pressures in other areas. Another critical issue is the complete lack of information on the pressure being maintained at various points of the system. Pressure gauges have been installed at the pump houses & WTPs at Lalpur, Bhongadwar and Ranjhi. But more pressure gauges need to be installed at locations like OHTs and at tail end of the distribution system. Further the gauges that last for too short period call for a change in procurement practices.

Pressure management is one of the key aspects that MCJ needs to address so as to ensure adequate service levels, minimize the leakages and ensure long term sustainability of the infrastructure. In the current situation, wherein the water supply is for limited duration, excess pressure may not be an immediate issue but maintaining adequate pressure in the network should be a priority. However, in a long term a pressure management strategy should be formulated and it should take into account the variation in pressure in the system on a 24-hour time scale and results be analysed to assess leakage from the system.

### *5.11.1 Implementation plan*

***Short and medium term measures***

1. The first step to management would be monitoring pressure using pressure gauges. It is thus recommended that a detailed survey of the entire network be conducted to establish the locations for installation of pressure gauges. Recommended locations include the transmission network, outlets of OHTs and critical locations in the distribution network (like locations where pipelines split into two or more distribution lines). Such an exercise may also be necessary to carry out a hydraulic network modelling exercise of the city. It is proposed that at locations mentioned above should have a quick fit coupling after a small stop cock. The pressure gauge can be clipped in when required. This method is more suitable than a permanent gauge as it is prone to get damaged soon.
2. In addition to pressure gauges it is also recommended that pressure loggers may be installed at select locations in the network which can give a 24 hour detailed pressure profile.
3. Selection of localities for pressure management could also proceed hand-in-hand with the auditing of water. As a part of the pilot study, pressure gauges should be installed at various locations at Brahman Colony and Satyanand Vihar.
4. A pressure gauge replacement/retrofitting programme may also be undertaken to enable monitoring of pressure on a regular basis. Since the quality and life of gauges is an issue of concern it is recommended that pressure gauges certified by BIS be used.
5. Analysis of the pressures in the system should be used as an input to the network modelling exercise, which may result in identification of critical stretches, in the network for the infrastructure replacement programme.
6. Location of pressure gauges should be marked in GIS database.
7. A system of recording and documenting pressure should also be developed.

***Long term***

In the long term it is envisaged that the city would move from an intermittent supply system to a 24-hour water supply system. Pressure management in such a context is an important tool for controlling leakages. The basic principle behind pressure management is that the pressure required in the system is not the same throughout the day and during non-peak hours controlling pressure can lead to a significant reduction in water losses without even plugging leaks.

### *5.11.2 Obstacles in implementation*

Major hindrance in the assessment of pressure in the network of Jabalpur is its undulating topography. Since pressure keeps changing with every alternative elevation and slope, the number of measurement points needs to be large for a precise mapping. This would therefore require a significant manpower and financial investment for comprehensive monitoring.

***A list of recommended projects is available in Table 5.4 and 5.5 on the following pages.***

**Table 5.4** Pilot projects for immediate implementation

| S. No. | Proposed pilot project | Location | WDM strategy* | Remarks |
|---|---|---|---|---|
| 1 | Installation of bulk meters | • Inlet from Gaur river<br>• 30-inch and 16-inch, two 12-inch pipelines from Bhongadwar WTP<br>• Inlet and outlet of lalpur WTP<br>• Inlet from sump well to Ranjhi<br>• Outlet of Ranjhi WTP<br>• Pump house at High Court | Bulk metering of flow | Ideally meters should be installed at all inlet and outlet of WTP, but for Bhongadwar WTP, it is recommended that bulk meters at the inlet should be installed after replacing transmission pipes from Khanduri dam to Bhongadwar WTP |
| 2 | Installation of V-notches/ level gauges | Open channel from Pariyat Dam to Ranjhi | Bulk metering of flow | |
| 3 | Checking, calibration and repair / replacement of Bulk revenue meters | All consumers with ferrule size greater than 3-inch $\phi$ | Bulk revenue meters | |
| 4 | Identify and establish DMA | Brahman Mohalla, Satyanand Vihar | District metered areas | Test run the possibility of a round the clock water supply and analyze performance |
| 4.1 | Installation of domestic meters | | Domestic consumer meters | |
| 4.2 | Water audit | | Water auditing | Should be carried out for two seasons |
| 4.3 | Extensive primary survey in pilot area to identify location of pipes using GPS and updating in GIS | | Database development and management using GIS | |
| 5 | Energy audit and analysis of pump efficiency | Ranjhi and Fagua pump houses | Energy Auditing | May ultimately lead to replacement/repair |
| 6 | Assessing the changes in water quality in pipelines | Brahman Mohalla, Satyanand Vihar | Water Auditing | |
| 7 | Identification of visible and underground leaks in distribution network using sounding rods and updation of this information in GIS | • All pipes in transmission lines with ferrule size greater than 8-inch diameter<br>• Brahman Mohalla, Satyanand Vihar | Active and Passive Leakage control | |
| 8 | Repair of visible leakages from the distribution lines | • All pipes in transmission lines with ferrule size greater than 8-inch diameter<br>• Brahman Mohalla, Satyanand Vihar | Active and passive leakage control | |

| S. No. | Proposed pilot project | Location | WDM strategy* | Remarks |
|---|---|---|---|---|
| 9 | Replacement of valves, pipes and repair of joints | Brahman Mohalla, Satyanand Vihar | Asset Management Program | 1. To display how to undertake repairs on pipelines without affecting the supplies<br>2. To assess expenditure required to carry out replacement for entire city |
| 10 | Identifying need for repair and renovation of infrastructure at the WTP | • Fagua and Gour Pump house<br>• Ranjhi Pump house No. 1<br>• Pipes from Khanduri to Bhongadwar<br>• Common collection sump from Fagua and Pariyat<br>• Repair of notch to Ordinance factory Khamariya from Pariyat | Asset Management Program | |
| 11 | Identifying need for repair and renovation of different water reservoirs | Select tanks (Kulli Hill tank, etc) | Asset Management Program | |
| 12 | Inspect and inventorization of ingress to water pipelines from sewage | Brahman Mohalla, Satyanand Vihar | Asset Management Program | |
| 13 | Switchover to modernized technology for tanker filling and repairs | Select tankers | Alternative supply means | |
| 14 | Introducing water kiosk, small pipe supply systems | 1 tanker supply zone | Alternative supply means | |
| 15 | Rainwater Harvesting | On roof tops of select tank reservoirs, administrative establishments, WTP (Lalpur WTP) and government colonies | Alternative supply means | |
| 16 | Analysis of the pressure system | Brahman Mohalla, Satyanand Vihar | Pressure management | Result in identification of critical stretches to help in replacement of the non-functioning pressure gauges |

| S. No. | Proposed pilot project | Location | WDM strategy* | Remarks |
|---|---|---|---|---|
| 17 | Identifying and regularizing the illegal connections and formulating a policy for regularization of illegal connections | Maddar Challa Area, Ghammapura | Regularization of the illegal connections | Local plumbers should be involved<br>Options:<br>1. Payment of electricity and water bill together at same counter<br>2. Door to door bill collection |
| 18 | Regularizing connections in cases where more than one family is served on a single connection | Brahman Mohalla, Satyanand Vihar and select zones | Regularization of the illegal connections | |
| 19 | Awareness campaign | Brahman Mohalla, Satyanand Vihar, Madaar Challa and Ghammapura | Consumer awareness | |

* For details, refer WDM strategy at Chapter 5

**Table 5.5** Proposal for projects to be implemented within 2 years

| S. No. | Proposed pilot project | Location | WDM strategy* | Remarks |
|---|---|---|---|---|
| 1 | Installation of bulk meters | Inlet and outlet of all treatment plants | Bulk management meters | |
| 2 | Installation and replacement / repair of old level gauges | All OHTs | Bulk management metering | |
| 3 | Regular flow measurement using ultrasonic flow meters | • At different points in rising mains and distribution network<br>• Important pipe junctions of pipelines like junction near Katinga crossing where water from Bhongadwar and lalpur meet. | Bulk management metering | |
| 4 | Checking, calibration of bulk revenue meters and repair / replacement of unsound meters | All bulk consumers | Bulk revenue metering | |
| 5 | Energy audit and analysis of energy savings | Pump houses at 3 treatment plants | Energy auditing | |
| 6 | Repair of all visible leakages | Pumping stations, WTP, stand posts, supply reservoirs, valves and transmission lines | Active and passive leakage control | |
| 7 | Repair of tankers to reduce leakages | All tankers | Alternate supply means | Linked with pilot implementation |
| 8 | Mapping details of tube well, hand pumps, slum areas | Select locations in Brahman Mohalla | Database development and management using GIS | |
| 9 | Capacity building of the supervisory and managerial staff | Engineers, managerial staff | Capacity building | • Leakage detection<br>• GIS<br>• Project management<br>• Financial management<br>• Water and energy auditing |

| S. No. | Proposed pilot project | Location | WDM strategy* | Remarks |
|---|---|---|---|---|
| 10 | Changing the existing system for bill collection by making the existing system simpler. Different options that could be tested include generation of a joint electricity and water bill collection | Select areas (Pilot areas recommended above could also be recommended for such implementation) | Financial reforms | |
| 11 | Generating financial resources by means like subletting infrastructure for advertisements | • OHTs<br>• Water bills | Financial reforms | |
| 12 | Change the existing system for recording of data and identify data needs for developing a MIS system | • Pump house level at WTP<br>• At different supply reservoirs | Institutional reforms | |

* For details, refer WDM strategy at Chapter 5

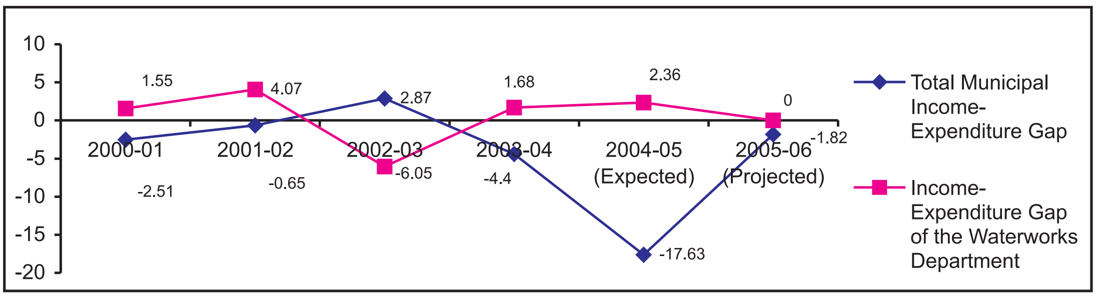
# 6 Financial Assessment of Waterworks Department, Municipal Corporation of Jabalpur

## 6.1 Background

The Municipal Corporation of Jabalpur (MCJ) is primarily responsible for administration and maintenance of water supply and sewerage system within the municipal limits of Jabalpur city. Till 1995, all water projects/schemes were operated & maintained by the Public Health and Engineering Department (PHED), which is organizationally responsible to the Madhya Pradesh State Government. After the passage of the 74th Constitutional Amendment, the PHED transferred all its assets to the MCJ for maintenance purposes. However, till date, some PHED staff is on deputation to the MCJ, especially for the Narmada Water Scheme. The salary for such employees is borne by the PHED and is allocated to the MCJ as annual administrative grants. Moreover, the planning, design and construction of water schemes continues to be the responsibility of PHED. As highlighted for other municipalities, the institutional and operational arrangement between the MCJ and the PHED needs to be unambiguously laid down for sake of financial transparency.

In audited/actual income terms, the share of the Waterworks Department in total income of the Municipal Corporation (from all sources) has varied between 10.89% in FY 2000-01 and 11.45% in FY 2003-04. In the FY 2004-05, this share is expected to be 11.16%. However, during FY 2005-06, the annual Municipal Corporation income is projected to be Rs. 143.11 crores, of which the Waterworks Department is expected to contribute Rs. 10.16 crores i.e. a meagre 7.10%. This share decline is largely attributed to a substantial projected increase in property tax collections from shop owners. On the expenditure front, the share of Waterworks Department to the Municipal Corporation expenses has fluctuated from 7.50% in FY 2000-01 to 20.10% in FY 2002-03 and subsequently to 8.07% in FY 2003-04. However, the expenditure share is projected to decline to 6.21% in FY 2004-05 and to 5.08% in FY 2005-06.

The income-expenditure gap of the Municipal Corporation and the Waterworks Department from FY 2000-01 to FY 2003-04 and projected gap for FY 2004-05 and FY 2005-06 is presented in the graph below:




It can be observed from above that except in FY 2002-03, the Waterworks Department has positively contributed to the overall Municipal Corporation finances. In terms of financial performance also, the Waterworks Department has been consistently in profits, except in FY 2002-03. However, as the Waterworks Department follows the cash-based accounting system, its revenue account excludes the outstanding liabilities in a particular financial year. There also exist several inconsistencies in financial reporting as some major expenditure items are being directly borne by the Government and not accounted for in the budget books. This aspect is dealt in greater detail in the analysis of various expenditure items presented below. Therefore, in the following income-expenditure analysis, the current and projected profit is incorrect to the extent of the discrepancy introduced by the existing cash based accounting system and the expenditure under-reporting. A summary of the financial position of Waterworks Department is given in Table 6.1.

**Table 6.1** Income-Expenditure Position of the Waterworks Department

(In Rs. Crores)

| S.No | Financial Year(s) | Annual Income | | Annual Expenditure | |
|---|---|---|---|---|---|
| 1. | 2000-01 | 5.57 | CAGR = 5.52%z | 4.02 | CAGR = 9.10% |
| 2. | 2001-02 | 7.01 | | 2.94 | |
| 3. | 2002-03 | 7.71 | | 13.76 | |
| 4. | 2003-04 | 6.90 | | 5.22 | |
| 5. | 2004-05 (Expected) | 7.80 | | 5.44 | |
| 6. | 2005-06 (Projected) | 10.16 | | 7.36 | |

The following sections appraise the financial position of the Waterworks Department based on the available actual budget figures from FY 2000-01 to FY 2003-04, the expected figures for FY 2004-05 and projected performance for FY 2005-06. The water tariff schedule, which became effective from FY 2001-02, is considered for analysing the Municipal Corporation existing tariff structure and methodology. The current assessment also relies on inputs from senior officials of Municipal Corporation and the PHED.

*The structure of this analysis is similar to that followed for financial assessment in other project cities. Accordingly, this section initially discusses the various components of income-expenditure statements of the Waterworks Department and 3 alternative scenarios are built over the Short, Medium and Long-term. Thereafter, the existing water tariff schedule is analysed. The section concludes by presenting some broad recommendations that are specific to the MCJ's Waterworks Department.*

## 6.2 Analysis of income-expenditure statement

As in other ULBs in Madhya Pradesh, the Municipal Corporation of Jabalpur follows the single entry, cash-based accounting system. This reporting system is inherently imprecise as it only accounts for payments made or receipts obtained in a particular financial year, which may or may not have actually originated in that year. Moreover, most of the billing procedure is manual, which obviously constrains an effective tracking of revenue collection and recovery. The MCJ has undertaken only limited computerization of municipal systems and procedures for revenue-expenditure management and budget preparation, as well as for maintaining mandatory registers for accounts reporting purposes. Currently, there exists no separate financial statement(s) reporting for the Waterworks Department. Moreover, the current financial reporting procedure does not distinctly record all sources of revenue and expenses pertaining to water supply at one particular place. Therefore, for purposes of appropriate reporting of finances for the department, we have considered all components in the budget statements pertaining only to the Waterworks Department.

The income from water supply operations of the Municipal Corporation increased from Rs. 5.57 crores in FY 2000-01 to Rs. 6.90 crores in FY 2003-04. This upward trend in annual income levels of MCJ can be primarily attributed to better revenue realization from water charges. The consolidated income statement of the Waterworks Department along with its various components is highlighted in the Table 6.2.

**Table 6.2** Municipal Corporation of Jabalpur: Income statement (FY 2000-01 to FY 2005-06)

| S. No. | Item | FY 2000-01 (Actual) | FY 2001-02 (Actual) | FY 2002-03 (Actual) | FY 2003-04 (Actual) | FY 2004-05 (Expected) | FY 2005-06 (Projected) |
|---|---|---|---|---|---|---|---|
| **Water Tax** | | | | | | | |
| 1 | Water Tax Outstanding | 1.57 | 2.08 | 1.02 | 1.75 | 1.00 | 1.50 |
| 2 | Water Tax (Size 3/8", 1/2", 3/4" Bulk, Tri-monthly, Contonment, Commercial etc.) | 4.00 | 4.93 | 1.50 | 5.15 | 0.80 | 1.20 |
| 3 | Sawrna Jyanti Connection (10000 connections at Rs. 300/- each) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | Outstanding from Bulk Consumers of above 1" pipe connection size | 0.00 | 0.00 | 5.19 | 0.00 | 5.00 | 5.50 |
| 5 | Compulsory Water Charge Outstanding/Current | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 1.50 |
| 6 | Temporary Households near Swami Dada Baburao Piranjpe Smriti (10000 connection, Rs. 300/- per connection for Re. 1 per connection) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 |
| 7 | Conversion from illegal to legal connection | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 |
| 8 | Income from Water Tanks (For Business, Marriage and other programmes) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| | **Total Income – Waterworks Department** | **5.57** | **7.01** | **7.71** | **6.90** | **7.80** | **10.16** |
| **Loans from Financial Institutions** | | | | | | | |
| 1 | Third Part of the Loan under Narmada Water Supply Scheme | 0 | 0 | 0 | 3.01 | 6.60 | 0 |
| | Sub-Total: Loans from Financial Institutions | 0 | 0 | 0 | 3.01 | 6.60 | 0 |
| **Grant from Government for Waterworks Department** | | | | | | | |
| 1 | Grant from Government for Waterworks Department | 0.00 | 0.73 | 0.20 | 0.30 | 0.30 | 1.50 |
| 2 | Lalpur Water Supply Scheme (Towards Salary) | 0.71 | 0.47 | 0.55 | 0.41 | 0.53 | 0.75 |
| 3 | Earthquake Surcharge related to Narmada Water Scheme | 0.00 | 3.85 | 0 | 0 | 0 | 0 |
| | Sub-Total: Grants from Government | 0.71 | 5.05 | 0.75 | 0.71 | 0.83 | 2.25 |

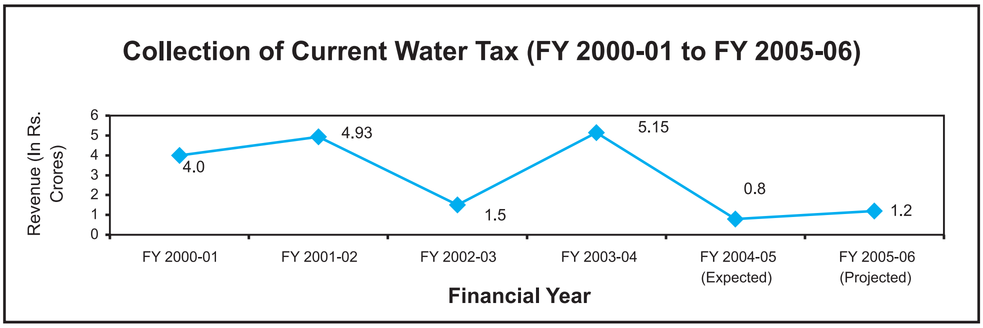
The expenditure of the Municipal Corporation towards water supply operations has also registered a broad increasing trend from Rs. 4.02 crores in FY 2000-01 to Rs. 5.22 crores in FY 2003-04. The component-wise actual and projected expenditure of the Department is given at Table 6.3.

**Table 6.3** Municipal Corporation of Jabalpur: Expenditure statement (FY 2000-01 to FY 2005-06)

| S. No. | Item | FY 2000-01 (Actual) | FY 2001-02 (Actual) | FY 2002-03 (Actual) | FY 2003-04 (Actual) | FY 2004-05 (Expected) | FY 2005-06 (Projected) |
|---|---|---|---|---|---|---|---|
| 1 | Establishment Expenditure | 2.14 | 2.10 | 2.15 | 2.23 | 2.36 | 2.60 |
| 2 | Expenditure on Electricity for water Supply | 0.72 | 0.40 | 8.45 | 1.04 | 0.18 | 0.20 |
| 3 | City Water Supply & Distribution | 0.03 | 0.05 | 0.10 | 0.20 | 0.44 | 0.50 |
| 4 | Water Distribution Repair & Maintenance (R&M) | 1.13 | 0.13 | 0.40 | 0.14 | 0.42 | 0.50 |
| 5 | Expenditure on Narmada Waterworks Project (Maintenance of Lalpur Pump House from Admn. Grants) | 0.87 | 0.90 | 0.36 | 0.46 | 0.66 | 0.75 |
| 6 | Operation & Maintenance of Other Pump Houses | 0.00 | 0.27 | 0.30 | 0.208 | 0.6227 | 2.08 |
| a. | Pariyat Fagua Pump House Plant | | | | 0.003 | 0.06 | 0.50 |
| b. | Ranjhi Pump House and Filteration Plant | | | | 0.020 | 0.04 | 0.30 |
| c. | Khandari Katteyaghat Plant | | | | 0.001 | 0.06 | 0.25 |
| d. | Bhoghadwar Filter Plant | | | | 0.024 | 0.02 | 0.15 |
| e. | City Pump House | | | | 0.00 | 0.05 | 0.10 |
| f. | Tube Well Pump House | | | | 0.00 | 0.25 | 0.35 |
| g. | Provision for other Pump House Maintenance and Repair | | | | 0.160 | 0.14 | 0.2 |
| h. | Development of Colley Hills | | | | 0.00 | 0 | 0.2 |
| 7 | Repair and Maintenance of New Hand Pumps | – | – | – | – | 0.003 | 0.03 |
| 8 | Expansion of pipelines for new private connections | – | – | – | – | – | – |
| 9 | Expenditure incurred on digging for New Hand Pumps | – | – | 1.32 | 0.45 | 0.51 | 0.50 |
| 10 | Water Materials | 0.00 | 0.00 | 1.04 | 0.96 | 0.90 | 0.95 |
| | **Total Expenditure** | **4.02** | **2.94** | **13.76** | **5.22** | **5.44** | **7.36** |
| **Expenditure under the third part of the 3rd Phase of the Narmada Water Scheme** | | – | – | – | 3.80 | 4.56 | 0.00 |
| | **Income–Expenditure Gap** | **1.55** | **4.07** | **–6.05** | **4.69** | **8.96** | **2.80** |

Apart from the various cost items highlighted above, our stakeholder consultations revealed that the expenditure, as stated in the Municipal Accounts, is currently grossly under-reported. This is because Government of Madhya Pradesh (GoMP) is on an average paying Rs. 4.8 crores annually (for past 3 years) towards electricity payments to the MPSEB. Further, expenditure on temporary labour and on Petroleum, Oil & Libricants (PoL) are being aggregated for all departments of the Municipal

Corporation and not segregated specifically for the waterworks department. In case all these expenses are accounted for, the income-expenditure gap can be expected to widen substantially.




Presented below is the sub-component wise analysis of the income-expenditure statements of the Department.

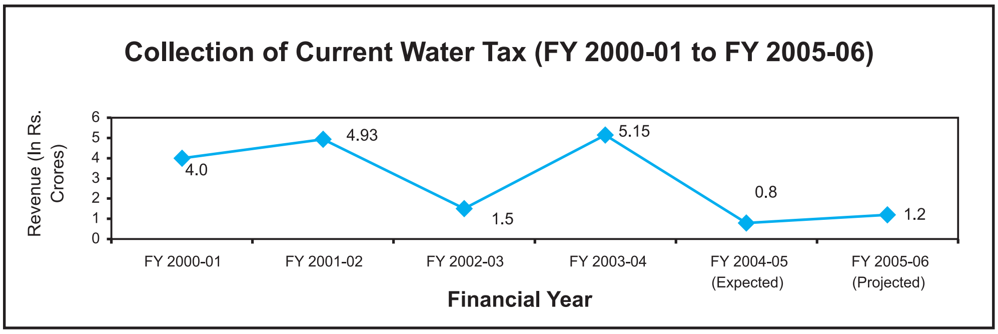
### *6.2.1 Analysis of income statement*

#### a. Income from own sources

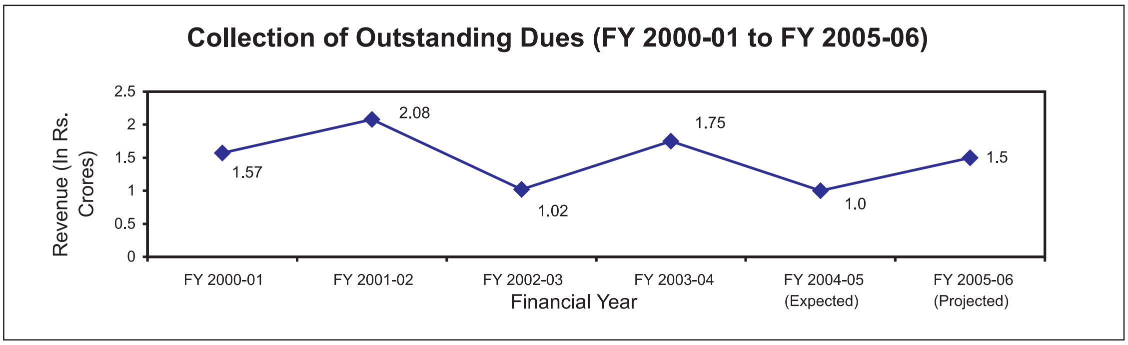
According to the current financial reporting, the Waterworks Department of MCJ records its entire revenue under 'Water Taxes'. Within this head, income is broadly derived from 2 sources, viz. recovery of outstanding dues and collection of current water tax. Apart from these sources, revenue is inadequately reported in the financial statement. This is evident from the fact that important revenue sources such as 'Income from water tanks' and 'Outstanding dues from bulk consumers' have sporadic reporting across all financial years under study. Given below is the component-wise analysis of income for the Waterworks Department:

- **Current water tax:** The Waterworks Department does not currently segregate its revenue from water tax according to originating source/consumer i.e. domestic, commercial and bulk. Interaction with Municipal Corporation officials suggests that a major portion of total revenues of the waterworks department comes from the bulk consumers. This is supported by the fact that the city has four large defence industries and also houses the High Court, State Electricity Board and the Department of Telecom Training Institute.

According to the budget documents the water tax collections have increased from Rs. 4.0 crores in FY 2000-01 to Rs. 5.15 crores in FY 2003-04 representing a CAGR of 8.78%. However, collections are projected to drop substantially to Rs. 0.80 crores in FY 2004-05 and Rs. 1.20 crores in FY 2005-06. The year-on-year revenue trend from this source is shown below:




- **Outstanding water tax dues:** One noteworthy aspect of the income statement of Waterworks Department is that it regularly reports the collection of outstanding dues in various financial years. However, our field visit revealed that the dues reported for a particular year may or may not have been billed in that financial year. As stated earlier, this anomaly is due to the cash based system of accounting being currently followed by the Waterworks Department. The trend of revenue from collection of outstanding dues is presented below:

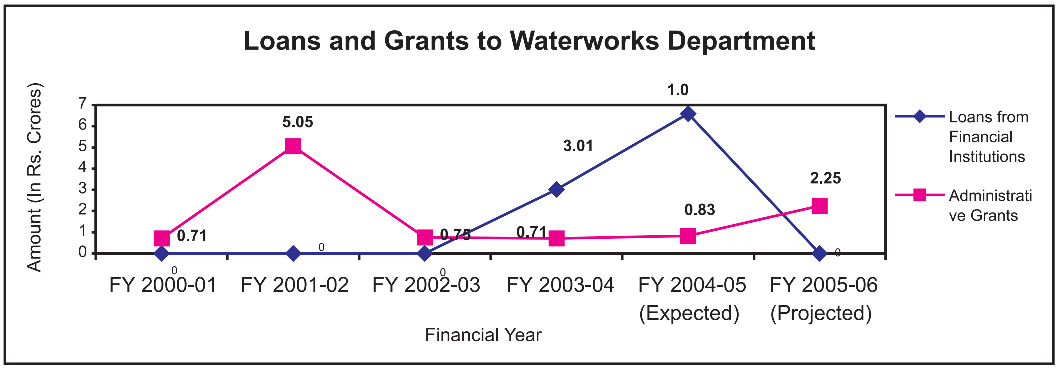



Additionally, the MCJ has reported that Rs. 5.19 crores was collected from outstanding dues of bulk consumers only during one financial year i.e. 2002-03. From the foregoing review, it is obvious that reporting under various heads of the income statement is currently inconsistent and unclear.

### b. Loans from Financial Institutions and Administrative Grants

The MCJ has taken loans from financial institutions, especially HUDCO for the completion of Narmada Phase III scheme proposed to augment water supply to the city by about 40%. HUDCO made disbursements for this scheme starting FY 2003-04. As loans represent a liability, the expenditure statement should reflect an annual interest component towards servicing the loans.

Moreover, the Waterworks Department receives annual grants from the Government towards payment of salary for PHED staff on deputation to the Municipal Corporation, especially for the Narmada water supply project. It may be noted that the above analysis does not include administrative grants for computation of annual profit/loss levels of the Department. The trend of disbursal of loan & grants to the waterworks department is shown in the graph below:

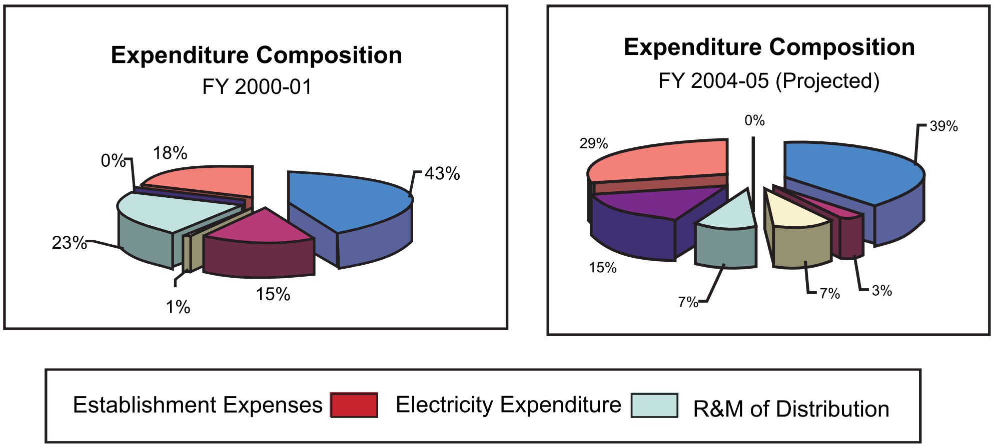



### *6.2.2 Analysis of the expenditure statement*

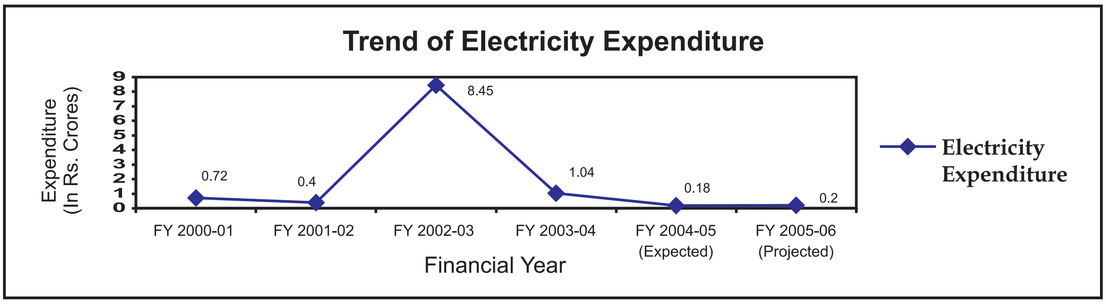
The Waterworks Department generally reports its expense items under 4 major heads i.e. City water supply & distribution network; Repair & Maintenance (R&M) of water distribution infrastructure; Narmada Waterworks Project (Maintenance of Lalpur Pump House) and O&M of Pump Houses. However, a perusal of the Municipal Corporation's budget statement suggests that two other expense items pertaining to water supply operations are being recorded separately in MCJ's consolidated accounts i.e. establishment expenditure and expenses on electricity. In the analysis below, TERI has aggregated such components to the expenditure of Waterworks Department, so as to ensure a more realistic assessment of financial performance and management.

The graphs below show the major contributing sources of total expenditure of the Waterworks Department for FY 2000-01, FY 2004-05 (Expected) and FY 2005-06 (Projected).

The component wise break-up of the department's major expenditure items is discussed below:

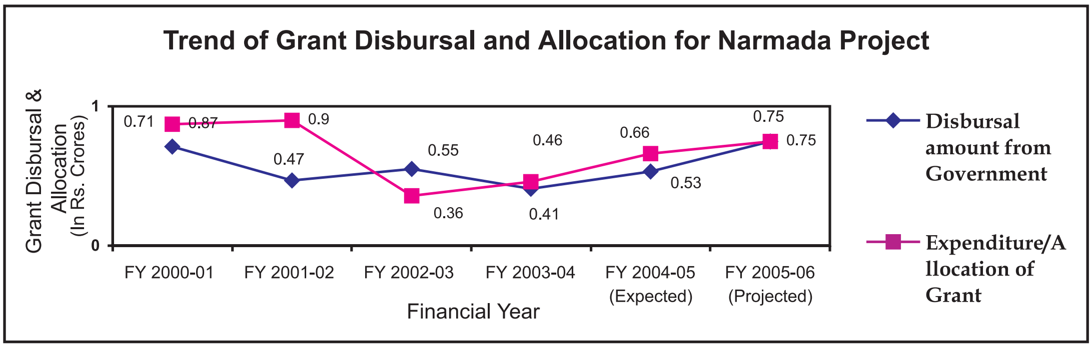



- As highlighted earlier, Establishment expenses pertaining to water supply operations of the MCJ are currently reported separately in the Municipal Corporation accounts and not specifically as part of the Waterworks Department. However, for prudent financial reporting, this component should be treated along with other expense items of the Department. This is because establishment expenses generally comprise of 'salaries and other allowances', which in most ULBs is a substantial portion of Municipal Corporation expenditure on water supply operations. In the current context, establishment costs have consistently been over 35% of the overall expenditure of MCJ's Waterworks Department. The expenditure trend has also been fairly stable at over Rs. 2.0 crores per annum during the period under study.
- Currently, the expenditure on Electricity for water supply operations reflects an extremely irregular trend. In an ideal situation, this expense component should have a rising trend, counterbalanced by an annual efficiency improvement from adoption of energy conservation strategies. The annual trend of electricity expenditure is shown in the graph below:




The irregular expenditure on electricity consumed and sudden spikes in the trend (FY 2002-03) reflect that either the MCJ is not consistently paying its dues to MPSEB or its demand fluctuates on an annual basis. Since the latter is unlikely, it can be inferred that the abrupt increase in electricity expenditure during FY 2002-03 was on account of arrears paid to MPSEB. Moreover, the recent report of GHK International confirms that the Waterworks Department has substantial accrual of non-debt liability owed to the MPSEB.

- For the period under study, the expenditure incurred on **City Water supply distribution** has shown a rising trend. This expenditure has grown from a minuscule Rs. 0.03 crores in FY 2000-01 to Rs. 0.20 crores in FY 2003-04, reflecting a whopping CAGR of 97%. Even though this trend is encouraging, the annual expenditure on this component needs to be shored up substantially for effecting any major improvement in water supply delivery in Jabalpur.
- The expenditure on **Repair & Maintenance (R&M) of MCJ's water distribution network** has shown a decreasing trend from Rs. 1.13 crores in FY 2000-01 to Rs. 0.14 crores in FY 2003-04. However, the Department has projected this expenditure component to increase to Rs. 0.42 crores in FY 2004-05 and further to Rs. 0.50 crores in FY 2005-06. It can be readily observed that currently only a minuscule portion of the total expenditure of the Department is being allocated for repair & maintenance works. This is a cause of concern, as with the passage of time, increased investment would be required to maintain the water supply infrastructure. The Department should therefore increase its financial allocation for regular R&M, especially of plants and pipelines, so as to improve efficiency and quality of water supply.
- **Operation & Maintenance (O&M) of Pump Houses:** This expense component, reflecting the O&M on major pump-houses within Jabalpur, reflects a rather irregular annual trend. While no expenditure reporting has been done under this head during FY 2000-01, it has broadly fluctuated between Rs. 0.27 crores in FY 2001-02 and Rs. 0.20 crore in FY 2003-04. However, this expenditure is projected to increase to Rs. 0.62 crores in FY 2004-05 and to Rs. 2.08 crores in FY 2005-06.
- **Other Expenses:** Apart from the above mentioned expenditure heads, the Municipal Corporation also records expenses on R&M of new hand-pumps; expansion of pipelines for new private connections; expenditure on digging for new hand pumps and water materials. Currently, limited financial reporting is done under all these heads.
- **Expenditure on Narmada Waterworks Project:** This expense component reflects the allocation of administrative grants by the department towards maintenance of Lalpur Pump House under the Narmada project. As stated earlier, for sake of accounting clarity, this item should not be aggregated with other expenditure items incurred solely for MCJ's water supply operations. Presented below is the trend of grant disbursal and allocation for the Narmada Project.




It can be readily observed that for many financial years, the grant expenditure/allocation has been higher than the initial grant disbursal. The gap is being obviously camouflaged in the current financial reporting as a routine expenditure.

### *6.2.3 Summary of income-expenditure analysis and collection efficiency*

Based on the income-expenditure details provided by the Municipal Corporation, the Table 6.4 presents the profit/loss position of Waterworks Department in two scenarios viz. if grants are not grants as income sources (as in above analysis) and if they are included as income for the department.

**Table 6.4** Profit/Loss position of Waterworks Department

| Financial year | Profit/Loss (In Rs. Crores) | |
|---|---|---|
| | Grants considered as Income | Grants not considered as Income (Current Analysis) |
| FY 2000-01 | +1.38 | +1.55 |
| FY 2001-02 | +8.22 | +4.07 |
| FY 2002-03 | -5.66 | -6.05 |
| FY 2003-04 | +1.93 | +1.68 |
| FY 2004-05 (Expected) | +2.54 | +2.36 |
| FY 2005-06 (Projected) | +4.30 | +2.80 |

The above Table clearly indicates that inclusion of administrative grants as income sources increases the profit/reduces the income-expenditure gap for the financial years under study. However, for accounting clarity, administrative grants should be separately reported and not aggregated with the water supply income and expenditure. It is worth mentioning that appropriate accounting of grants/transfers from the State Government is of utmost importance and under no circumstance its allocation be utilized towards routine Municipal Corporation expenditure.

***Collection efficiency***

The Municipal Corporation currently follows an annual billing cycle for domestic consumers, as the water tax is generally charged along with the property tax. For bulk and commercial consumers, billing is either done on a monthly or quarterly basis. Field surveys revealed that collections are constrained by non-availability of bill-collecting staff at the zonal level. Moreover, staffing for meter reading purposes is inadequate and billing records for commercial consumers is maintained manually. The Municipal Corporation officials also admitted that collection procedures and penalty mechanism for non-payment of dues was not being vigorously pursued & adhered. Given below (Table 6.5) are the collection efficiency estimates based on the available information of revenue demanded and recovered during a particular financial year:

**Table 6.5** Collection efficiency (1999-00 to 2003-04)

| MUNICIPAL CORPORATION OF JABALPUR – Waterworks Department Collection Efficiency (1999-00 to 2003-04) | | | |
|---|---|---|---|
| | | Water charges for current year | Collection efficiency (In particular year) |
| 1999-00 | Demand | 7.00 | |
| | Recovery | 5.49 | 78.39 |
| 2000-01 | Demand | 7.50 | |
| | Recovery | 4.05 | 54.06 |
| 2001-02 | Demand | 7.50 | |
| | Recovery | 4.93 | 65.80 |
| 2002-03 | Demand | 10.30 | |
| | Recovery | 5.34 | 51.89 |
| 2003-04 | Demand | 10.30 | |
| | Recovery | 5.15 | 49.97 |
| 2004-05 | Demand | 7.10 | |
| | Recovery | 4.09 | 57.62 |

**Source:** Municipal Corporation Documents

Obviously, with higher levels of collection efficiency, the revenues and hence profits of the Department could improve further, thereby making available additional internal funds for augmentation & maintenance of water supply infrastructure.

### *6.2.4 Inconsistencies and data gaps in financial statements*

One of the most essential principles of revenue and expenditure management is the methodical maintenance of accurate and up-to-date financial information. In this context, there are certain data gaps in MCJ's financial statements, which are summarized below:

- Currently, there is limited reporting in the income statement on revenues received from various consumer categories. The revenues from water taxes are being aggregated together, rather than being attributed to domestic, bulk, commercial and industrial categories. Such customer category-wise information should be maintained to ensure greater accounting clarity.
- The expenditure statement of Waterworks Department does not currently report the establishment and electricity expenses, as these items are recorded separately in Municipal Corporation accounts. Being major expenditure contributors, these components should be aggregated along with other expenses on water supply operations of the Municipal Corporation.
- There exists limited information on the current and past liabilities (including bad debts) of the Municipal Corporation. Field visits and interaction with Municipal Corporation officials suggest that the total outstanding amount of the department as on March 2005 stands at approximately Rs. 20.00 crores. In its Budget statements for FY 2004-05 and FY 2005-06, the Municipal Corporation has made provision of Rs. 50 lakhs towards repayment of amount outstanding for the Waterworks Department. Moreover, the Waterworks Department does not have a bad-debt policy. For better financial management, the department should prepare a summary of liabilities and identify the recoverable and non-recoverable portions of the same.
- The Municipal Corporation is currently reporting 'Expenses on Narmada Water Project' in its Expenditure Statement. However, this component should be separately accounted, as it is an annual administrative grant. It is therefore imperative to scrutinize all grants from Government and restate them correctly in the financial statements.
- The Waterworks Department follows a cash-based system of accounting, in which a transaction is recorded only when there is a movement of cash. In other words, entries are made in the cashbook only when expenditure is incurred or when income is received. Under the cash-based system, receipts & expenditure do not differ on the basis of time period (current/previous) and type (revenue/capital). Therefore, this system inherently fails to provide the correct financial position of the Municipal Corporation. Hence, it is suggested that the department should move to the accrual-based system of accounting. This system is elaborated later in this section as part of the recommendations.

## 6.3 Current water tariff structure

MCJ has a multi-facet water supply tariff for metered and unmetered consumers. In its tariff schedule (revised in 2001-02), the Jabalpur Municipal Corporation has broadly classified its customers as Residential/Domestic, and Non-Domestic (Commercial, Industrial and Bulk). A flat tariff structure is being currently followed by the MCJ. Even though few domestic meters exist, they are not in functioning condition and billing is done at a flat rate. However, some bulk consumers are being charged a volumetric rate based on metering. The exact level of metering in bulk consumers is not readily available.

For all domestic consumers, the Municipal Corporation charges a fixed service charge, levied on an annual basis along with the property tax collection. The fixed amount from each category has been broadly classified on the basis of furrule size (i.e. diameter of the supply pipe). Additionally, the Municipal Corporation has specified the volumetric rates for domestic and non-domestic consumers, the implementation of which would obviously depend on the level of metering.

The second part of the schedule lists the other charges (Raw water and presentation charges). However, no rate is specified for new water connections, pay water from municipal tanks and legalization charges etc. The tariff schedule also does not indicate the applicable tariffs for above 4" ferrule connections. The existing water tariff schedule is presented at Table 6.6.

**Table 6.6** Existing tariff schedule (effective FY 2001-02)

| **MUNICIPAL CORPORATION OF JABALPUR – Waterworks Department<br>Water Tariffs (Effective from 2001-02)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **S.No.** | **Customer Category** | **Ferrule Size** | | | | | |
| | | 1/2" | 3/4" | 1" | 1-1/2" | 2" | 4" |
| **Domestic Category** | | | | | | | |
| 1 | Minimum Charge per month | 60 | 120 | – | – | – | |
| 2 | Volumetric Charge for Metered Connections | Rs. 3/KL | | | | | |
| **Non-Domestic Connections** | | | | | | | |
| 2.A | Minimum Charge Per month | 270 | 540 | 810 | 1620 | 2430 | 7290 |
| 2.B | Volumetric Charge for Metered Connections | Rs. 9/KL | | | | | |
| **Other Charges** | | | | | | | |
| 3 | Raw Water | Rs. 3/KL | | | | | |
| 4 | Presentation Charge: According to the Madhya Pardesh Municipal Act 1956, the applicable water rates for Acting Schools and Public Entertainment Shows | First Class: Rs. 15/ show | Second Class: Rs. 12/ show | Third Class: Rs. 7/ show | | | |
| **Exemption from Water Charges** | | | | | | | |
| 5 | Freedom Fighters owning a Domestic (1/2") connection have been granted exemption from payment of water charges during their liftetime | | | | | | |

As stated earlier, the above water tariff rates were made effective from FY 2001-02. Prior to this, the non-domestic volumetric water tariff was Rs. 6.00 per thousand liters. The tariff rates have also been hiked for provision of raw water from Rs. 1.5 to Rs. 3 per thousand liters. However, there have been no changes in domestic water tariffs.

### 6.4 Rationalisation of tariff structure

Currently, MCJ follows a method of charging flat rates for domestic water supply, primarily because of non-functional metering at the consumer end. This flat-charge methodology is inherently based on the following two assumptions.

- It takes approximately the same amount to service each customer, irrespective of the water amount supplied and the time of supply.
- The Waterworks Department is able to recover all costs, irrespective of the consumption level.

As these two assumptions generally do not hold true, this methodology of charging flat tariffs for water supply leads to inefficiencies as well as defies economic logic. A flat tariff not only encourages indiscriminate and illegal water usage, but also acts as a disincentive for consumers to conserve water.

An alternative to the current tariff structure is the 'two part' tariff structure. Such a tariff design typically includes a consumption/ volumetric rate in addition to the fixed water charge. The former is primarily a variable charge that recovers costs based on usage. The two-part tariff design is beneficial over current structure as it encourages conservation, recovers costs of holding unused capacity for peak demand and reflects tariff efficiencies for servicing various customer categories. International literature on water tariff reform suggests that the following factors determine the structure of two-part tariff:

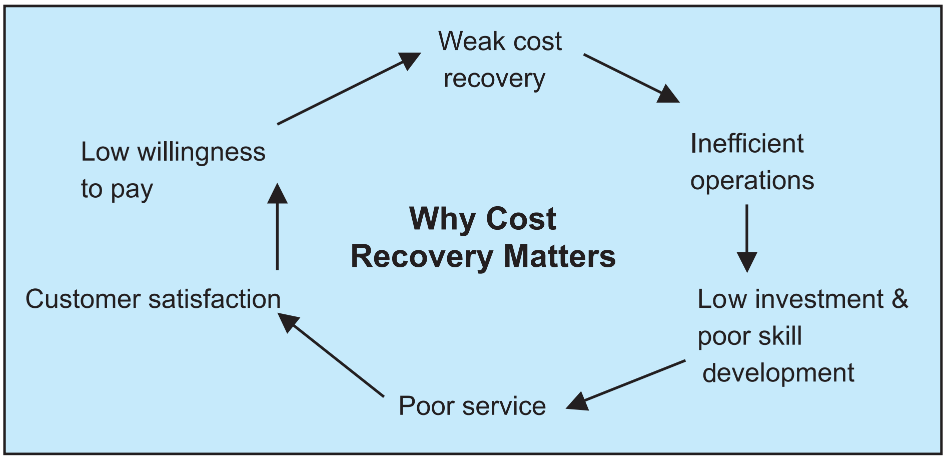
- Level of metering (total, partial or no metering)
- Extent of cross-subsidization between consumer classes
- Number of customers and disproportionate customer structures (e.g. numerous high volume users or high proportion of small volume users)
- Fluctuations in demand patterns during different times of the year
- Age of the system that determines the level of operating & capital cost requirements
- Existing rules and water tariff structure

To operationalise the two-part tariff structure, the Waterworks Department needs develop appropriate information and monitoring systems that collect and report the following financial details:

- Allowable costs and cost allocation procedure
- Profit, return on investment and return on assets i.e. the Department is allowed a mark-up or return over its economic costs
- Tariff setting procedures

It should be noted that two-part tariff structures are most suited for metered systems. Field visits by our project team have shown that currently there is metering amongst some commercial & bulk consumers and they are being charged a volumetric rate. However, the exact quantum of revenue generated from metered water system is difficult to estimate, as the exact number of commercial/ bulk meters is not readily available with the Municipal Corporation.

Additionally, the existing tariff structure needs to be rationalized to address cost recovery principles, incentivise metering, improve collection efficiency and provide clarity to tariff design. In this context, it is important to discuss in detail the concept and relevance of the full cost recovery (FCR) principle. FCR for water services primarily covers all costs associated with operating, maintaining and financing a Municipal Corporation's water system. In other words, this concept implies that revenues from water sales, primarily through tariffs, are equal to or exceed the amount required to cover all costs related to obtaining, processing and distributing water to the ULB's customers. Therefore, revenues should not only cover the Operation & Maintenance (O&M) costs, but also if possible, the depreciation, taxes and cost of capital. Clearly, achieving FCR can be an important determinant of a utility's ability to improve and expand service/infrastructure. There are however several factors that typically inhibit a utility from embracing the FCR principles. These include political pressure against water tariff increases, operational inefficiencies, poor water supply infrastructure and mismanagement of existing resources. The diagram below highlights the importance of Cost Recovery and its inter-relationship between technical, financial and governance factors:




**Source:** Regional assessment survey & workshop on full cost recovery for water utilities in Southeast Asia: Sharing international experience & best practices

While improved water pricing strategies are one of the important mechanisms for improved cost recovery, financial sustainability also depends upon other factors, such as sound financial management, technical expertise, infrastructure coverage, balanced water consumption and production, low Non Revenue Water (NRW), effective metering & record keeping, billing & collection practices and quality of service (QoS). The afore-mentioned factors are detailed as part of the recommendations in the section below. Meanwhile, it is important to note that any reform measure should not only focus on the tariff design/structure, but also on the underlying economic logic (cost recovery principles) behind rate setting.

The existing tariff structure in Chennai, Bangalore and Delhi are given in Annexure 6.1. Before we discuss the approach to be adopted for tariff rationalisation of the MCJ, it is also important to study the experience in other sectors (especially electricity) with respect to tariff reforms.

**Box 6.1** Electricity Tariff Reforms in India

One of the most important demand side management measures in infrastructure service provision is designing an appropriate tariff structure based on cost allocation principles. Since the early 1990s, the power sector in India has been going through a process of reforms and restructuring. Undoubtedly, the most important problem in this sector is irrational tariff structure. Before the setting up of Regulatory Commissions at the state level, the tariffs were being fixed and realised by the State Electricity Boards and Electricity Departments. However, the state governments have constantly interfered in this process so as to provide concessional tariffs to certain sectors – mainly agriculture and domestic consumers. These sectors are generally cross-subsidised by the commercial and industrial sectors and also directly subsidised by the government. At the same time, the SEBs are not adequately subsidized for this loss in revenue and they have been incurring heavy losses. The attempt to make up these losses by raising industrial tariffs has led to increasing migration out of the grid through the captive generation route. As a result, the financial position had been deteriorating every year.

The Electricity Act 2003 notified in June 2003, empowers the SERC's to specify the terms and conditions for the determination of tariff and ensure transparency in the tariff setting process. SERC's have to constitute proper measures to allocate revenue requirement in an economically efficient manner by reducing the extent of cross subsidies. This is primarily achieved by increasing the low-tension (LT) tariff to a greater extent as compared to high-tension (HT) tariff. The Act also provides the guidelines and the procedure to be adopted for the purpose of tariff determination and issuing of tariff order. The draft National Tariff Policy was introduced in March 2005. Till date, 21 states have already issued their first tariff orders aimed at rationalizing tariffs.

A number of commissions have instituted measures to allocate revenue requirement in an economically efficient manner by reducing the extent of cross subsidies. This has primarily been achieved by increasing the LT tariff to a greater extent as compared to the HT tariff. Also, a number of commissions have initiated an increase in the tariff of agricultural consumers despite it being a highly politicized issue. However, in some states including Andhra Pradesh and Maharashtra, the state government decided to continue fee power to agricultural consumers and this led to huge burden on the state's finances. In Andhra Pradesh, there were considerable debates and discussion on the issue and it was finally decided that the subsidy that will be provided to farmers will have to be target properly and criteria for the same were established. There is also a movement towards determination of tariff based on the cost of supply approach. These regulatory reforms have in-turn resulted in a progressive reduction in the differential between average tariff and average cost of supply, as well as a greater orientation to base tariffs on cost allocation principles.

### *6.4.1 Approach*

Based on available financial information, our analysis reveals that the Waterworks Department needs to rationalise its existing tariff structure. As the first step, revenue under the base case scenario, i.e., the existing scenario has been estimated to assess the current financial position of the Municipal Corporation. The base case scenarios are based on the existing tariff schedule of the MCJ. There are two base case scenarios as per this schedule:

**Base Case Scenario 1**: Case when all domestic revenue comes from levy of fixed charges.

**Base Case Scenario 2**: Case when revenues come from variable charges (variable charge is the Rs./KL charge that the MCJ has in its tariff schedule for metered customers who pay on the basis of actual consumption).

However, field surveys and discussion with the MCJ has revealed that at present there is limited domestic metering at the consumer level and therefore Base Case Scenario 2 mentioned above does not exist in actuality. The MCJ only has a provision in its tariff schedule for charging consumers on the basis of their consumption, but since there is domestic metering, this is not taking place.

As the next step, revenues that the MCJ would generate in three alternative scenarios have been estimated. These three alternative scenarios have been prepared to assess the financial situation of the MCJ in future and thereby suggest tariff reforms. These are scenarios corresponding to short term, medium term and long term. The commencement and terminal years for the three scenarios envisaged for tariff rationalisation and reform are given at Table 6.7.

**Table 6.7** Commencement and terminal years for the 3 alternative scenarios

| Scenario | Commencement year | Terminal year |
|---|---|---|
| Short Term | 2006/07 | 2007/08 |
| Medium Term | 2008/09 | 2009/10 |
| Long Term | 2010/11 | 2011/12 |

In this study, we have analyzed the existing financial position and tariff structure of the MCJ and suggested changes that need to be made for it to move forward on the path of tariff reforms.

All the above scenarios are based on certain critical assumptions that had to be made in the absence of requisite information. Data on category wise consumption, water loss level, revenue billed and collected, etc was not provided as according to the Municipal Corporation such database is not maintained by it. The basic requirement of tariff reforms is a robust database. These assumptions are discussed in greater detail in the section that follows.

The expenditure of the MCJ under various heads for the above three scenarios has also been projected. This is explained in detail later. The resulting gap between the revenue and expenditure is the amount that the MCJ would need to recover through tariff rebalancing and further efficiency improvements.

### *6.4.2 Tariff rationalisation*

The assumptions that have been made to assess the revenue-expenditure status of the Municipal Corporation are given below:

a. Based on flow estimation and evaluation, the total water supply to Jabalpur city is estimated at 151.0 MLD (excluding bulk consumption).

b. The water transmission and distribution loss is estimated at about 30% (or 45.3 MLD).

c. Based on the above assumptions, water available for consumption by domestic, commercial, industrial and bulk categories is approximately 105.7 MLD.

d. The cumulative consumption of industrial and commercial consumers is estimated to be 13.8 MLD.

e. Based on water balance analysis & some assumptions, the water supplied to tankers, public standposts and religious places is approximately 0.2 MLD, 2.8 MLD and 1.7 MLD respectively.

f. The water available to domestic consumers is approximately 87.3 MLD.

g. Based on flow estimation and evaluation, illegal water consumption in Jabalpur is about 45.3 MLD. The number of illegal connections is estimated to be about 50,669.

h. Water left for legal domestic consumption is estimated to be 42.0 MLD. Based on available Municipal Corporation estimates and some assumptions, the number of domestic water connections is approximately 46,969.

i. As per the Census of India 2001, the household size in Jabalpur is 5.0 (urban+rural). However, for the purpose of this study, the average household size in Jabalpur is assumed to be 9. This is primarily based on observations made during the field survey that more than one family staying together have taken only one connection. Further, it was also observed that portions of houses have been sub-let and a second connection has not been taken for that.

j. The total population being currently served water by the Municipal Corporation is approximately 4,22,721 based on the average household size of 9.

k. Based on all the above-mentioned assumptions, the per-capita consumption of connected population works out to be 99.3 lpcd.

l. Collection efficiency is 100%: Since the Municipal Corporation follows a cash-based accounting system, the correct level of annual collection efficiency cannot be estimated. TERI has estimated the revenues from the number of connections as provided by the Municipal Corporation for different consumer categories and from the consumption as estimated based on the assumptions above. Therefore, the estimates assume 100% collection efficiency.

m. All commercial and bulk consumers are being currently charges a volumetric rate of Rs. 9/KL. This assumption has been taken due to lack of information on exact number of bulk/commercial-metered connections & some of the commercial consumers being currently charged a volumetric tariff.

n. Due to unavailability of data on break-up between ½" and ¾" ferrule size connections, we have assumed all domestic connections to be of ½" diameter.

The box below summarizes these assumptions:

**Box 6.2**

- Total water supply – 151.0 MLD
- Water Loss during T&D – 45.3 MLD (30% of total water supply)
- Water available for consumption – 105.7 MLD
- Commercial/Industrial and bulk consumption – 13.8 MLD
- Water to Tankers – 0.2 MLD
- Public Stand posts – 2.8 MLD
- Religious Places – 1.7 MLD
- Water left for Domestic Consumption – 87.3 MLD
- Illegal consumption – 45.3 MLD
- Number of illegal connections – 50,669
- Water left for legal domestic consumption – 43.5 MLD
- Average Household Size – 9.0 members, Population connected – 4,22,721
- Per-Capita Consumption of connected population (domestic) – 99.3 lpcd

### *6.4.3 Base case tariff scenario*

**Base Case Scenario 1**: Only fixed charges are levied for domestic category & volumetric charge for all commercial & bulk consumers - Based on the above-mentioned set of assumptions and existing fixed tariff rates, the expected revenues for FY 2003-04 are highlighted Table 6.8.

**Table 6.8** Base Case Scenario 1

| S.No | Customer Category | Ferrule Size | No. of Connections | Consumption MLD | Fixed charge Rs/Month | Variable charge Rs/KL | Revenue from fixed charge Rs Crore |
|---|---|---|---|---|---|---|---|
| 1 | Domestic | 1/2" | 46969 | 42.0 | 60 | | 3.38 |
| | | 3/4" | 0 | 0.0 | 120 | | 0.00 |
| | Sub-Total | | 46969 | 42.0 | | | 3.38 |
| 2 | Non-Domestic (Commercial, Industrial and Bulk) | 1/2", 3/4", 1", 1-1/2", 2", 4" and above | | | | | |
| | Sub-Total | | 485 | 13.8 | | | 4.52 |
| 3 | Public Standposts | | – | 2.8 | 0 | | 0.00 |
| 4 | Worship Places | | – | 1.7 | 0 | | 0.00 |
| 5. | Water to Tankers | | – | 0.2 | | | |
| | | Total | 47454 | 60.4 | | | 7.90 |

The above table shows that the MCJ should earn Rs 7.90 crore through revenue from tariffs in a given financial year. However, as per the financial data provided by the MCJ, it actually collected Rs 6.90 crore in FY 2003-04. It can be inferred from above that the difference may be due to the set of assumptions taken in the foregoing analysis or the cash based system that currently constrains the proper reporting of accounting information.

The Table 6.9 gives the consumer category wise tariff per connection and the cost per connection of the Municipal Corporation as per existing information and data.

**Table 6.9** Existing consumer category-wise average tariff and average cost

(Rs/KL)

| S.No. | Customer Category | Tariff/Connection Rs/Connection | Cost/Connection Rs/Connection | Difference Rs/Connection |
|---|---|---|---|---|
| 1 | Domestic | 720.0 | 1111.3 | -391.3 |
| 2 | Non-Domestic | 93131.4 | 1111.3 | 92020.1 |
| | Total | 1664.5 | 1111.3 | 553.1 |

The above table shows that at present, MCJ is charging its non-domestic consumers, (comprising of industrial and bulk) substantially more than the costs being incurred to provide water to them and correspondingly undercharging the domestic category. This implies that in the existing tariff structure, high level of cross subsidy exists especially for the domestic category.

**Base Case Scenario 2:** Variable charges are levied as per the schedule of the Municipal Corporation for tariffs based on actual consumption. This case obviously assumes the extreme scenario in which there is a 100% metering and water tariffs are completely volumetric.

**Table 6.10** Base Case Scenario 2

| S No | Customer category | Ferrule size | No. of connections | Consumption<br><br>MLD | Variable charge<br><br>Rs/KL | Revenue from variable charge<br><br>Rs Crore | Total revenue<br><br>Rs Crore |
|---|---|---|---|---|---|---|---|
| 1 | Domestic | 1/2" | 46969 | 42.0 | 3.00 | 4.6 | |
| | | 3/4" | 0 | 0.0 | 3.00 | 0.0 | |
| | Sub-Total | | 46969 | 42.0 | | 4.6 | 4.6 |
| 2 | Non-Domestic (Commercial, Industrial and Bulk) | 1/2", 3/4",1", 1-1/2",2",4" and above | | | | | |
| | Sub-Total | | 485 | 13.75 | 9.00 | 4.5 | 4.5 |
| 3 | Public Standposts | | | 2.8 | 0 | 0.0 | 0 |
| 4 | Worship Places | | | 1.7 | 0.0 | 0.0 | 0 |
| | | Total | 47454 | 60.2 | | | 9.1 |

As per Base Case Scenario 1, the MCJ earns Rs 7.9 Crore in a given financial year. In Base Case Scenario 2, this figure rises to Rs 9.1 Crore, i.e., an increase of 15%. In other words, the Municipal Corporation will earn nearly 15% more revenues from levying variable charges as compared to the revenue it generates through the levy of only fixed charges. It is also imperative to ascertain whether or not the various customer categories, especially domestic, would be willing to pay an additional 15% for the existing quality and reliability of water services. Further, as the customers would be paying more under variable charges, it implies that there exists limited incentive for them to move to metering. Therefore, the Waterworks Department needs to carefully examine its tariff structure so as to determine the appropriate charges for the various customer categories. These should not only promote efficiency, equity and metering but also help it to achieve financial sustainability.

### *6.4.4 Analysis*

To assess the alternative revenue-expenditure scenarios in terminal years of the short (FY 2007-08), medium (FY 2009-10) and long-term (FY 2011-12), TERI has used the available financial information from FY 2000-01 to FY 2003-04. For undertaking this analysis, the component-wise expenditure trend of the Waterworks Department was studied and subsequently a suitable growth rate was determined for each component. This methodology is detailed below:

The Waterworks Department reports its annual expenditure under four broad heads i.e. City water supply & distribution network; Repair & Maintenance (R&M) of water distribution infrastructure; Narmada Waterworks Project (Maintenance of Lalpur Pump House) and O&M of Pump Houses. Additionally, the Municipal Corporation Budget Book also reports establishment expenses and electricity expenditure pertaining to the water supply operations.

As already highlighted, the trend of various expenditure items of Waterworks Department has been extremely erratic over the past 4 years. Hence, no financial year can be considered as a representative base year for expenditure extrapolation over the short, medium and long-term. For purposes of data projection, we have therefore used an average estimate for each expense item.

The applicable growth rate on each expenditure item and the underlying rationale for choosing such trend rate is detailed below:

- Establishment expenditure is assumed to increase based on the average Consumer Price Index (CPI) for FY 2003-04 i.e. 3.9%.
- The electricity expenses for the Department are expected to follow the Wholesale Price Index trend (5.4% during FY 2003-04). However, as there is likely to be some efficiency improvement (3%) in energy usage over time, we assume the trend growth rate for this component at 2.4% annually.
- The expenditure on augmenting the City Water Distribution Network is assumed to increase at 5% per annum.
- R&M expense of Water supply network is expected to grow at about 8% over the short, medium and long term. This is primarily based on the assumption that more expenditure will be incurred by the MCJ in the coming years on R&M, as well as upgradation of the existing water distribution infrastructure.
- Expenditure on O&M of Pump Houses is expected to increase at 15.0% per annum. This figure is based on the trend growth of O&M in Jabalpur, as well as other cities of Madhya Pradesh such as Gwalior.
- Expenditure on water materials is assumed to increase at a marginal pace of 2% per annum.

Additionally, the short, medium and long-term scenarios assume:

- During the entire period, MCJ undertakes no tariff revision.
- Consumer category wise per-capita water consumption in Jabalpur city remains constant over the period under study (2006-07 to 2011-12).
- The annual increase in new water connections is approximately 3% for all consumer categories from 2008-09. Consumption by commercial and bulk categories is assumed to remain constant during the period under study.
- Illegal connections are assumed to follow a reduction trend as percentage of the previous year's illegal connections. The trend of regularising these connections will be as follows:

**Table 6.11** Trend of regularization of illegal connections

| Year | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 |
|---|---|---|---|---|---|---|---|
| Connections legalised (%) | | 30% | 30% | 25% | 25% | 20% | 20% |
| Connections legalised | Existing illegal connections: 50669 | 15201 | 10641 | 6207 | 4655 | 2793 | 2235 |

- It is assumed that correct reporting of connections based on household size and number of families staying in one house will take place gradually. This means that if two families are staying in one house, they will have to take two connections and accordingly pay for the same. It is assumed that the average household size will decrease from 9 to 6. The trend in achieving this is given at Table 6.12.

**Table 6.12** Additional connections due to changes in family dependence on a particular connection

| Year | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 |
|---|---|---|---|---|---|---|
| Additional Connections (%) | 20% | 25% | 30% | 30% | 30% | 30% |
| Additional connections numbers) | 8847 | 8847 | 7963 | 5574 | 3902 | 2731 |

Based on the above two assumptions, the total number of domestic connections will be as follows.

**Table 6.13** Total new domestic connections added during the short, medium and long term

| Year | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 |
|---|---|---|---|---|---|---|
| Total Domestic connections | 68285 | 87773 | 103270 | 114866 | 122969 | 129384 |

The income-expenditure position of the Municipal Corporation and the resultant gap in the terminal years in the short, medium and long-term scenarios is given in the Table 6.14 below.

**Table 6.14** Revenue-expenditure projections for waterworks department

(Rs. Crores)

| | Short-term | Medium-term | Long-term |
|---|---|---|---|
| | 2007-08 | 2009-10 | 2011-12 |
| Water Charges (Total) | 10.84 | 12.79 | 13.93 |
| Projected Revenue | 10.84 | 12.79 | 13.83 |
| **Expenditure:** | | | |
| Establishment Expenditure | 2.51 | 2.61 | 2.71 |
| Expenditure on Electricity for water supply | 2.91 | 3.06 | 3.20 |
| Expense on City Water Distribution Network | 0.11 | 0.13 | 0.14 |
| Water Supply Repair & Maintenance (R&M) | 0.61 | 0.66 | 0.71 |
| Operation & Maintenance of other Pump Houses | 1.14 | 1.31 | 1.50 |
| Expenditure incurred on digging for new Hand Pumps | 0.44 | 0.44 | 0.44 |
| Water Materials (operation costs) | 1.04 | 1.06 | 1.08 |
| Projected Expenditure | 8.77 | 9.63 | 10.65 |
| Projected Revenue-Expenditure Gap/Surplus | 2.07 | 3.16 | 3.18 |
| Annual Cost per Connection (In Rs./KL) | 1227.82 | 1108.32 | 1064.71 |
| Annual Tariff per Connection (In Rs./KL) | 993.30 | 834.68 | 820.07 |
| Difference (Average Tariff – Average Costs) | 234.52 | 273.64 | 244.63 |

It is clear from the above table that the MCJ is expected to be consistently in profits over the entire period under study. In fact, the differential between annual tariff and cost per connection is expected to improve over the short to medium term. However, as stated earlier, if expenses on PoL, electricity and temporary labour, which are currently borne by the Government, are accounted the profits reduce substantially and turn into losses over the short, medium and long-term period. With the afore-mentioned assumptions, the financial position of waterworks department, subsequent to the inclusion of expenses on PoL, electricity and temporary labour are as follows:

**Table 6.15** Income-Expenditure Gap (assuming expenses on electricity, PoL and labour)

| | 2007-08 | 2009-10 | 2011-12 |
|---|---|---|---|
| Income-Expenditure Gap (Assuming Electricity – Rs. 4.8 crores for past 2-3 years, Expenditure on labour & PoL*) | -5.62 | -5.39 | -6.31 |

* Inputs from senior MCJ officials

In view of the above table, it is imperative for MCJ to introduce prudent financial accounting practices, as the current profits are not reflective of the actual financial performance of waterworks department. There also exists a definite case for tariff rationalization, especially for domestic connections, as this would shore-up the revenues of the Waterworks Department and make available more funds for augmentation of the infrastructure.

### *6.4.5 Strategy*

The three scenarios for tariff rationalisation and reform in the short term, medium term and long term are given below:

1. Short term: Continuation of single part, fixed charge based tariff for all consumer categories. Volumetric charges will be introduced for consumers of those pilot areas where 100% metering takes place during this period.
2. Medium term: Two-part tariff (combination of fixed charge and variable charge) in approximately 40% of the area where 100% metering is completed. For rest of the areas, single part, fixed charge based tariff structure continues.
3. Long term: Transition to a two-part tariff structure with 100% metering in the entire city.

The important points that need to be considered while determining the category wise tariff rates in the above three scenarios are given below.

- In all the above scenarios, the variable charge should be gradually increased over the years as metering takes place and consumers start paying for the water they consume.
- Consumer categories that are not being charged for the water supplied, for example, worship places need to gradually start paying for the same. If the State Government wants to provide free water to these consumers, they need to provide subsidy to the Municipal Corporation for the same.
- The tariff schedule needs to be made more exhaustive, so that it clearly details the applicable charges for each consumer category, including bulk consumers. Tariff rationalization should also include some collection efficiency improvement measures for e.g. rebate/discounts on early payment and penalty of delayed payment.
- Continuation of lifeline slab for "poorest of poor" domestic consumers keeping in view their capacity to pay.
- Currently, there exists high level of cross subsidy in the existing tariff structure. Bulk consumers getting treated water and industrial consumers are subsidising the consumption of domestic, non-domestic, worship places and public stand-post categories. This cross subsidy should be gradually reduced and all categories be moved to pay the costs of supplying water to them.

However, as highlighted earlier, there is a need to continue lifeline tariffs for the 'poorest of poor' consumers.

- The Municipal Corporation needs to maintain an exhaustive database to be able to undertake tariff rationalisation. It should also maintain its accounts in the proper manner and they should be audited on time (Suggested formats for database at Annexure 6.2).
- Data required for tariff rationalisation should be collected in a manner such that it can be easily compiled in the format given in the table below.

Additionally, while undertaking any tariff rebalancing exercise, the MCJ needs to adhere to some basic principles of tariff setting. The tariff should also:

- Promote economic efficiency
- Non discriminatory tariff structure
- Simplicity of tariff design
- Avoid tariff shocks
- Internalise non-economic considerations

Undoubtedly, these are complex and multifold challenges. As tariff reforms are undertaken, customer expectations start evolving. This implies that the Municipal Corporation will have to pay adequate attention to improving the quality of supply and service. With increasing transparency and consumer awareness, the hidden inefficiencies and cross-subsidies driving tariff reforms are uncovered. The consumers expect to know the following:

- Whether the investments and expenditures are incurred prudently.
- Level of cross-subsidy and information on beneficiaries.
- Utility's plan for improving services

Therefore, the Municipal Corporation will have to take into consideration the above factors to be able to implement tariff reforms strategy successfully.

## 6.5 Recommendations & implementation plan

1. **Accounting system reforms:** An accounting system is efficient if it is able to provide updated, accurate and clearly defined information on finances. As highlighted earlier, municipal bodies in Madhya Pradesh (except Indore Municipal Corporation) follow a cash-based system of accounting, which is nothing but a summary of cash as per various accounting heads. Under the cash system, a periodic or annual statement called 'Receipts and Payments Account' (RPA) is prepared. In such financial statements, the 'receivable and payable information' is absent and to that extent, the correct financial position of a Municipality cannot be ascertained. For example, if water tariff from a particular consumer is due on a certain date, the cash based system is not capable of noting whether or not 'an amount is receivable or is yet to be received'. In other words, a transaction is reported only on its receipt, even though it was due/billed earlier.

In view of the above, it is suggested to modify the prevalent municipal accounting and financial reporting systems from single-entry cash based to double-entry accrual based system. The accrual system has already been adopted in several ULBs across Tamil Nadu & Maharashtra and in cities such as Hyderabad, Bangalore, Ludhiana and Jaipur. This system scores over the cash based accounting as it also takes into consideration credit transactions. Briefly, the accrual system of accounting provides the following additional information not provided by the cash system:

- Portion of income earned and portion outstanding/receivable.
- Expenditure of an organization during a period and the amount due/payable.
- The net worth of an organization i.e. assets owned by an organization and obligations owed by it.

The accrual system of accounting is based on the following three financial statements:

- Receipts and Expenditures
- Balance Sheet (Assets and Liabilities)
- Cash Flow Statement

Given below is a brief description of these financial statements:

*Receipts and Expenditure Statement* – This type of accounting statement gives a summary of transactions recorded in the books as well as transactions for which physical movement of cash has not taken place. It primarily informs the Municipal Corporation of the various heads under which transactions remain receivable or payable. For example, in case of water tax revenues, charges pertaining to a period are accounted as gross revenue in the receipt and expenditure statement, and the portion that remains uncollected is shown in the Balance Sheet as 'Water Tax receivable relating to a financial year'. Similarly, in case of water supply expenditure, the account shows the gross expenditure pertaining to that year, and the portion that remains unpaid is reflected in the Balance Sheet (e.g. rent payable or interest payment).

*Balance Sheet* – The balance sheet is a summary of all transactions of an organization since its inception and hence is supposed to indicate its cumulative financial position. It is termed as a balance sheet as it reflects balances carried over in the books of accounts from one financial year to the next. This statement primarily summarizes all capital transactions. It also reports revenue transactions (Surplus/ Deficit for the year derived from the Revenue- Expenditure Statement) reported under 'Fund Balance'. Additionally, the balance sheet provides information on both short-term assets and liabilities called the 'Current Assets and Current Liabilities' and on long-term assets and liabilities called the 'Fixed Assets and Long-term Liabilities'.

Cash Flow Statements are structurally similar to the 'Receipt and Payment Accounts'. However, it provides a summary of all cash transactions, whether revenue or capital.

Apart from shifting to the double-entry accrual system, MCJ should follow a more prudent system of accounts reporting. The existing reporting inconsistencies for the Municipal Corporation have been highlighted separately earlier.

**2. Introducing program-linked financing arrangements/Linking administrative grants to output & performance parameters:** The annual grants received by the Municipal Corporation from the Government should not only be linked to yearly fund allocation on waterworks, but also be tied to the actual benefits/output derived at each financing stage. It is widely recognized that an appropriately designed governmental transfer scheme for the municipalities can significantly hasten decentralization efforts and improve local service delivery of water supply.

Governmental transfers can be basically of two types:

- General transfers that allow local governments discretion in usage.
- Conditional transfers that are linked to usage and contribution to some activity.

However, the following 3 aspects need to be borne in mind while determining the transfer design:

- Transfers/Grants should not discourage efforts at the Municipal Corporation end to mobilize revenues.
- The grants scheme needs to be simple, transparent and predictable.
- There should be an independent and rigorous monitoring system to track utilization of administrative grants: This would enable an utility to generate reliable.

Currently, the MCJ is receiving an annual grant from the Government to improve pay water arrangements in Jabalpur city. However, there seems to be limited basis for this grant allocation, as the Municipal Corporation is not maintaining adequate expenditure accounts detailing grant utilization. This ad-hoc system of governmental transfers could ultimately result in unsustainable investments having limited delivery outcomes.

**3. Prudent financial management & planning:** As a first step towards financial sustainability, the Waterworks Department could tap additional revenue sources either by increasing user fees & charges/tariff rationalization, by ensuring maximum coverage & collection or by introducing new taxes & charges. The Municipal Corporation as a whole could raise resources through external funding such as municipal bonds (as done by Indore Municipal Corporation) and pooled financing. The alternatives available to Waterworks Department for resource mobilization are highlighted separately in various recommendations.

On the expenditure front, possibilities of savings through efficiency improvements should be vigorously explored. In this direction, adequate emphasis should be laid on setting & prioritisation of various expenditure items, as well as on justifying the geographic benefit of service provision. The Waterworks Department also needs to make provision for increases in expenditure on account of inflation, prior service commitments and uncommitted proposals for service expansion. Additionally, for effective planning and control of municipal expenditure, the Department could adopt the following measures:

a. **Municipal Action Plans**: Action planning at the municipal level has been widely implemented by ULBs in Brazil. This system is implemented in a phased manner i.e. from the level of strategic objectives to a medium term financial & programme plan, to an annual work programme and budget; and finally to a quarterly implementation plan.

b. **Performance Indicator**s: The annual expenditure performance of Waterworks Department could be assessed in terms of such indicators as cost-to-output ratio.

c. **Quarterly Rolling Plan**: Short-term quarterly plans could be implemented for ensuring continuity and more effective expenditure planning.

**4. Proper treatment of capital expenditure & depreciation:** The Waterworks Department is currently not segregating expenditure items as 'revenue' and 'capital' expenses. It can also be observed from the MCJ's financial statement that the Municipal Corporation is not considering the diminution in value of assets through wear and tear due to use, passage of time and obsolescence, in other words depreciation. Sound accounting practices require the value of fixed assets to be written off on a percentage basis (cost minus scrap value) over certain number of years against revenues of an organization. Presented below is a general approach on treatment of capital expenditure and depreciation.

Capital expenditure (primarily to augment infrastructure and improve quality and reliability of supply) and means of financing the same are critical inputs in determination of tariffs. The proper treatment of Capital Expenditure is exacerbated by the fact that new projects aimed at augmenting water supply infrastructure are generally long-term and require investments spread over a number of years. Therefore, the capital costs cannot be recovered from the consumer in any particular financial year and needs to be spread over a number of years.

The first step in treatment of capital expenditure is to apply two tests to determine whether such costs should be included in overall expenditure calculations. The 'used and useful test' examines whether the investment or expense was necessary for the provision of supply. A 'prudence test' asks whether or not the investment or expense was prudent or least cost option. In this context, it is important to compare available costing options of capital assets, as well as parameters such as reliability and quality of supply. A further consideration should be made on whether a capital expenditure due for completion towards the end of a financial period should be brought to account in the current regulatory period or deferred until the commencement of the next period. In the electricity sector, the capital expenditure is recognized when the assets are brought into service.

Another important consideration in the rate making exercise is treatment of capital expenditure as part of fixed assets, which are included in tariffs by a component of return on capital and depreciation on assets. These rates in-turn depend upon the capitalization policy of the Municipal Corporation/ service provider. The return on capital is calibrated to yield an acceptable rate of return to the investor (here, the Government) based on a reasonable level of capacity utilization and operating efficiency level. Simultaneously, depreciation on fixed/capital assets over its useful life should be duly accounted.

**5. Inventory & materials management:** Like all other ULBs, the Municipal Corporation of Jabalpur holds a significant amount of fixed assets. However, it has been observed that very few ULBs are currently exploiting the real commercial benefit of these properties to generate non-tax revenues. This is because of the following reasons:

a. Currently, ULBs (including MCJ) do not maintain proper records of asset inventories. This obviously constrains implementation of strategy for optimum utilization of resources and sound inventory management principles.

b. Generally, executives in the production & purchase departments take decisions relating to municipal inventories. However, sound inventory management requires the proactive involvement and participation of finance officials, who would help ensure that key resources are being efficiently monitored and controlled.

It is also necessary to devise methods to arrive at the optimum quantity of inventory based on the average consumption pattern, lead time and economic considerations such as cost of carrying inventory, procurement cost and stock-out cost. To gauge the effectiveness of inventory & materials management, it might also be useful for MCJ to examine the following ratios and indices:

**Table 6.16** Key ratios/indices measuring effectiveness of inventory management

| S. No. | Inventory Ratio/Index | Relevance |
|---|---|---|
| 1. | Material Inventory Turnover Ratio | Annual consumption of materials |
| 2. | Weeks' Inventory Turnover Ratio | Material inventory on hand/Weekly consumption of materials |
| 3. | Average age of Materials | Average materials inventory at cost/Average daily purchase of materials |
| 4. | Out of stock index | Number of times out of stock/requisitioned |
| 5. | Spare parts index | Value of spare parts inventory/Value of capital equipment |

6. **Sound billing and collection system**: As highlighted earlier, a sound billing system is extremely essential in respect of the duties and taxes levied by the municipal authority and the amount collectible from customers. This is because only a sound billing system can ensure timely serving of demand notice and collection of dues from customers, thereby enabling efficient cash recycling. A sound billing system generally has the following objectives:

a. Clear accounting of dues for various customer categories

b. Timely raising of bills for the water dues

c. Establishing time schedules between the time of raising the bills and serving the same to the customers

d. Paying adequate attention to disputed cases and defaulters

e. Accurate computation of arrears of dues in cases of water charge revision and ensuring their billing

f. Balancing of manpower with work load, involved in billing consumers

On the administrative front, the billing system should be decentralized to the extent possible. This system should also be amenable to incorporate changes in water tax rates/charges as and when they are imposed.

Our field visits reveal that while the MCJ has introduced computerization in its billing mechanism, information on customer-category wise connections and revenues is not readily available. Moreover, information on outstanding dues and bad debts is also not available with the Municipal Corporation. These lacunae in the billing system obviously need to be addressed & plugged at the earliest.

On the other side of the water charge recovery spectrum is an efficient and well-functioning collection mechanism. Broadly, the objectives of a sound collection system are as follows:

a. Collection from the consumers of the right amount and on due date

b. Facilitate willing consumers to pay at convenient collection centres such as bank branches and corporation sub-offices.

c. Prompt clarification to customers of disputed & incorrect items of billing

d. Accounting for daily collections and their remittances

e. Elimination of avoidable delays

f. Minimizing the cost of collection

g. Rigorous follow-up of defaulters

h. Establishing an efficient collection machinery/establishment

It is recommended that the Waterworks Department conduct an in-depth survey of customer clusters, so as to properly profile the convenience of key customer categories. Moreover, the Municipal Corporation could formalize a collection target and incentive mechanism for officials/ inspectors involved in dues collection from customers.

**7. Introducing fiscal autonomy:** An important indicator of fiscal autonomy for any Municipal Department is the extent of own resource mobilization to its revenue expenditure requirements. Clearly, regular assessment of this ratio could help assess the extent of autonomy or dependence of the Department on the overall municipal resources. In the context of water supply operations, the MCJ should ideally consider its Waterworks Department as a 'Profit Centre' and therefore devolve greater fiscal autonomy to it. Simultaneously, revenue-expenditure accounting/budgeting pertaining to its water supply operations should be done separately. While on the revenue front, the Department should be given greater independence on determination of new water charges/taxes and revision of existing tariffs; on the expenditure front, all expenses accrued solely on water supply operations should be accounted together and covered from revenue receipts of the department. This would enable the Municipal Corporation to accurately assess financial sustainability of water operations and undertake timely corrective measures wherever necessary.

# 7 Water Demand Management Strategy: Institutional and Policy Reforms

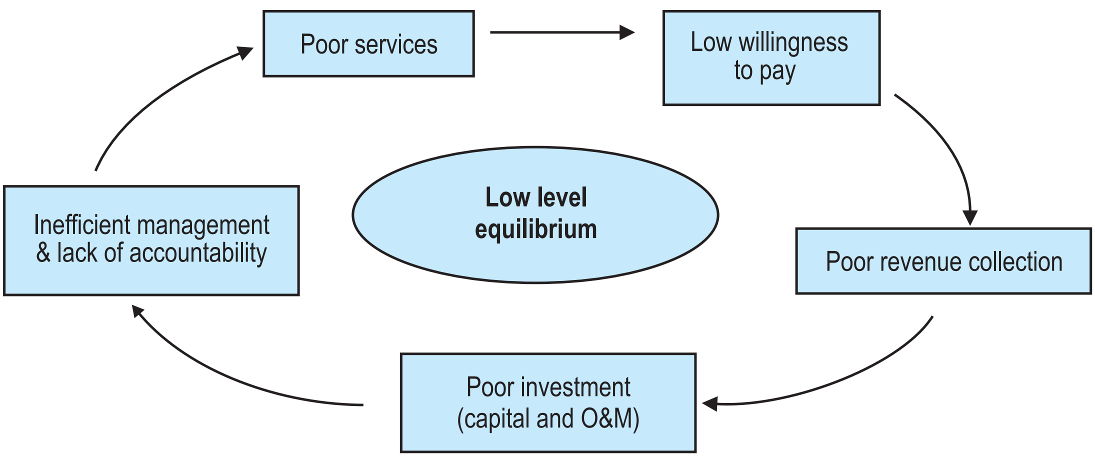
## 7.1 Introduction

To achieve the targets set out in the MP UWSEIP (Madhya Pradesh Urban Water Supply and Environmental Improvement Project) that of an improved coverage and transformation to a round-the-clock water supply system with significantly less losses (<15%), sweeping changes would be required in the way the municipal corporations functions today. The institutional structure of the organization needs to be geared up for promoting managerial efficiencies and ensuring a greater level of accountability. It is thus imperative to analyze the institutional issues plaguing MCJ and develop a reforms package to address these issues. This chapter tries to analyse the current institutional and legal framework for provision of water supply services in Jabalpur and suggest a strategy for future action. A SWOT (Strength, Weaknesses, Opportunities and Threat) approach has been followed to identify critical issues for MCJ. However since a SWOT is always more effective if carried out by the institution under consideration itself, it is also proposed to undertake a SWOT during the stakeholder consultations. Reform strategies to gear up MCJ towards better efficiency are thereafter suggested.

### 7.1.1 Rationale for reforms

It has been found that official reports tend to give much greater weightage to physical and financial progress rather than the quality, reliability and sustainability of water supply services (TERI 2002a, IRC 2003). Reported statistics usually indicate the population covered and hide important parameters like regularity or duration of supply, financial sustainability of the system, water security and long-term sustainability of the source.

The Urban water supply sector in India has traditionally been plagued with high levels of inefficiencies leading to poor service delivery and a high level of losses. The sector is characterised by a low level equilibrium (Figure 7.1) wherein the low level of service and poor accountability of the water utilities leads to a poor willingness to pay among the consumers which on the other hand translates into a financial crunch for the utility making any improvements including day to day O&M very difficult.




**Source:** Deb 2003

**Figure 7.1** Key issues in urban water supply: The vicious circle

Urban Local Bodies (ULBs) suffer from several deficiencies and are yet to respond adequately to emerging challenges posed by the rapidly changing urban scenario. The critical issues are service coverage and quality, per capita water supply, increasing demand for water, inequitable water supply, deficiencies in the treatment of raw water and in the distribution system along with poor revenue collection (Pachauri and Batra 2001). These drawbacks have in many ways resulted in the establishment of informal "*water markets*" where urban poor are the main sufferers and pay more than the affluent for the service.

The solution to water supply is often seen as capacity augmentation, rather than operating the existing capacity more efficiently. This bias in favour of new projects is partly due to the lack of accountability of agencies at both local and state levels and also because inefficient management of systems goes un-noticed (The World Bank, 1999). Over exploitation of groundwater, degraded watersheds, lower water supply and sanitation service coverage, poor construction and operation & maintenance can be traced to lack of monitoring and control, low tariffs and a lack of revenue to undertake development. High Non-Revenue Water (NRW) and low water accountability result from illegal connections, inadequate metering and meter reading and inadequate billing on one hand and from leakage of water on the other (McIntosh 2003). According to Pachauri & Sridharan (1998), since the low quality of service is the single biggest obstacle to the levy of reasonable user charges, efficient operation will help improve acceptability of higher user charges.

Further over the last decade, the responsibilities and problems to be tackled by the Urban Local Bodies (as managers and service providers) have increased manifold. The 74th Constitutional Amendment Act (CAA) has led to decentralization of powers and responsibilities to the Local Bodies. The Constitution thus envisages urban local bodies as being totally responsible for all aspects of development, civic services, and environment in the cities, going far beyond their traditional role. However these institutions as mentioned earlier are still in the process of building their financial capabilities and institutional capacities to address the issues in service delivery. It is a known fact that most municipal corporations in India face problems related to poor financial health, sub optimal service delivery levels, inefficiencies and a general lack of accountability.

This problem has been recognized at the national level and the tenth five-year plan aims to address the problem.

**Box7.1**

"……the focus should not only be on the investment requirements to augment supplies or install additional systems in sanitation and water supply. Instead, greater attention must be paid to the critical issues of institutional restructuring, managerial improvement, better and more equitable service to citizens who must have a greater degree of participation."

"Institutions dealing with water supply and sanitation have very little autonomy on personnel and financial matters. Information systems necessary for effective management are generally lacking."

**Source**: Twenty five year plan Document – Chapter 6.2

The Water works department of the Jabalpur Municipal Corporation was also found to be facing this problem. It is thus important to implement a reform package, which would essentially aim at putting in place a policy and institutional framework thus addressing the root cause of inefficiencies in MCJ.

The huge investment requirements for urban infrastructure and the policy directives of the national and state governments also make it necessary for the local bodies to reforms their governance and management structures. Annexure 7.1 details some of the reform initiatives being undertaken at the national level, which make it imperative for ULB's to enhance their efficiencies and ensure greater transparency and accountability in their functioning.

## 7.2 Current legal and institutional framework for provision of water supply services in Jabalpur

Water supply services in all towns of Madhya Pradesh are provided by the Municipal corporations/ municipalities in accordance with the provisions of the Madhya Pradesh Municipal Corporation Act 1956 and the Madhya Pradesh Municipalities act, 1961. The act governs the functioning of all ULB's, defining their powers and responsibilities. The composition of the Jabalpur Municipal Corporation has been fully ensured as per the provisions of the Act. The State Government has also nominated persons having special knowledge and experience in the municipal affairs recently. Wards committees/ Zonal Committees have also been constituted by Jabalpur Municipal Corporation as a step towards a decentralized approach. Jabalpur Municipal Corporation has been established according to the provisions of the Madhya Pradesh Municipal Corporation Act, 1956.

As per the act, MCJ is mandated with provision of water supply services in Jabalpur city and collecting charges/taxes for the same. It is vested with powers to source, treat and distribute drinking water supply in all areas of Jabalpur city. The specific responsibilities of water works department of MCJ are:

- Complete arrangement for water source, operation and maintenance of Intake wells, Filter plants, Storage and supply system.
- Operation, maintenance and replacement of main and distribution pipelines.
- Maintenance of public stands
- Arrangement for water through tankers etc at times of shortage.
- Registration of private tap connection and its maintenance.
- Maintenance of Nagar Nigam's private and public water sources, ponds, wells etc.

### *7.2.1 Institutional arrangement: MCJ*

In accordance with the $74^{th}$ CAA, Municipal Corporation of Jabalpur comprises of an elected body supported by administrative machinery. The elected wing consists of a Mayor and 60 elected councillors (one from each ward). A Mayor-in-Council is also in place according to the provisions of the MP Municipal Corporation Act, 1956 that constitutes of the Mayor and 10 council members chosen from the elected councillors.

The Urban Administration and Development department is the nodal department at the state level and is responsible for providing urban services in all cities and towns. The UADD allocates funds and provides policy directives for provision of urban service. In addition the PHED (Public Health Engineering Department) is mandated with the responsibility of design and execution of water supply and sewerage schemes, which are to be handed over to ULB's for operation and maintenance. Figure 7.2 gives the institutional arrangements for delivery of water supply services.

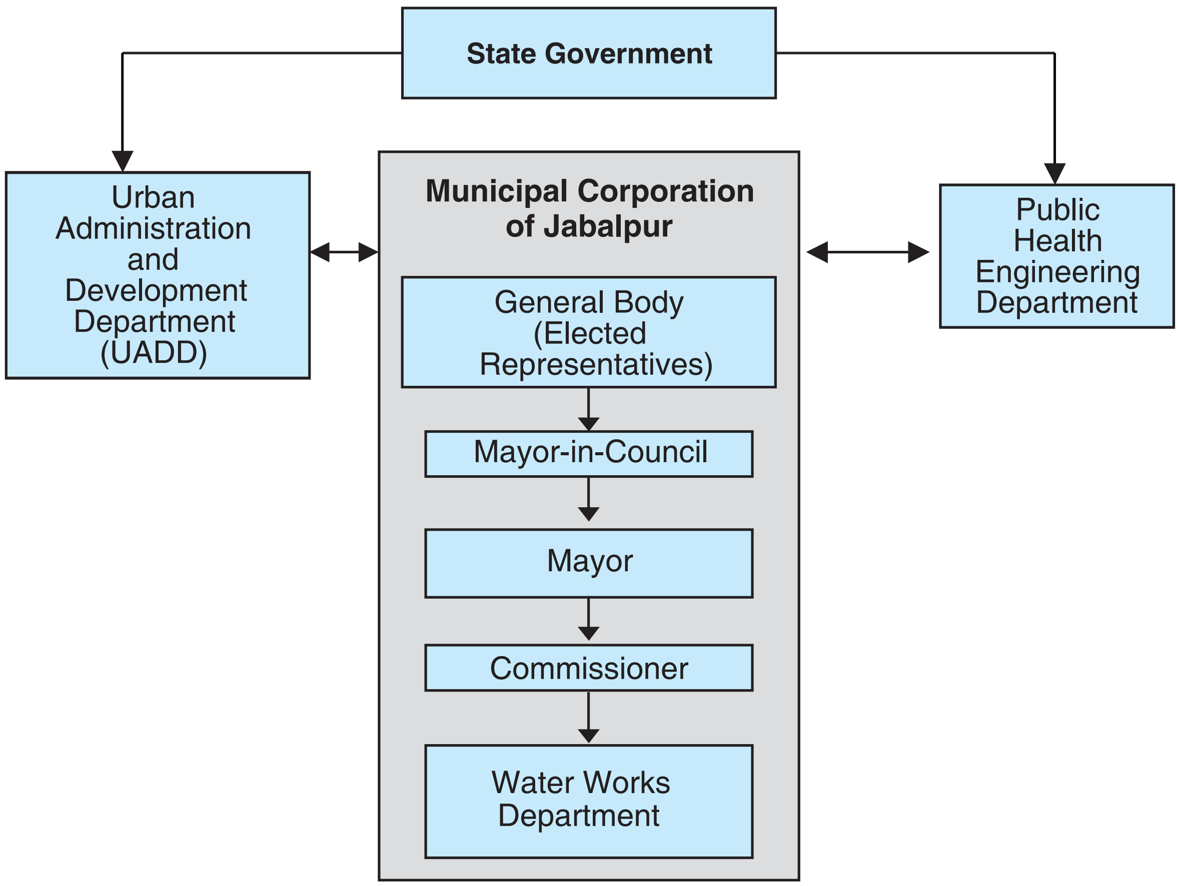



**Figure 7.2** Institutional arrangements in Jabalpur, Madhya Pradesh for provision of urban water supply

### *7.2.2 Composition of Municipal Corporation of Jabalpur*

**Elected representatives**

The MCJ comprises of 60 municipal councillors elected through direct elections from the wards headed by the Mayor.

**MCJ staff: Water works department**

Water supply operations in Jabalpur are headed by the Municipal Commissioner who is assisted by a team on engineers from the Water works department. Figure 7.3 below gives the institutional structure of the water works department

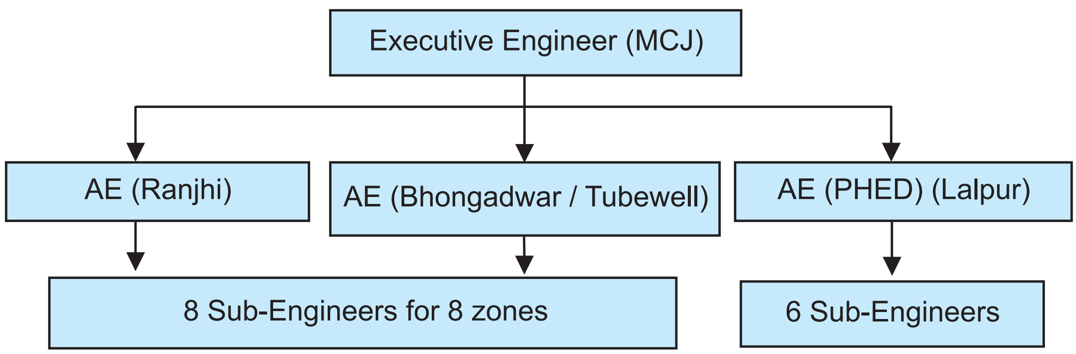



**Figure 7.3** Organisation chart for Water works department (MCJ)

The water works department in headed by an Executive Engineer who is assisted by three Assistant Engineers as shown in Figure 7.3. Under AE Ranjhi WTP, there are eight Sub-engineers, who are responsible for distribution of water in 8 zones in Jabalpur city. AE, Bhongadwar WTP is also responsible for Tube wells division apart from transmission and distribution from Bhongadwar WTP. Apart from these, there are 2 officials for hand pumps, 2 for head works near dam and 1 responsible for tanker supply in Jabalpur. All these officials come under MCJ.

Third AE from PHE Department is responsible for both treatment plant in Lalpur WTP and its distribution. Six sub-engineers work under him who is responsible for entire distribution from Lalpur WTP to households. These officials come under PHE Department, Jabalpur.

Zonal tax officers (8 zones) is responsible for collection of water tax and all records related to revenue collection are maintained by the zonal tax office. This information is subsequently passed on to zonal water works.

The total manpower in the water works department of MCJ as per records provided by MCJ are 376. (Details given in Table7.1 below). In addition staff from PHED is also deputed for maintenance of bulk supply lines.

**Table 7.1** Manpower in water works department

| | |
|---|---|
| Executive engineer | 1 |
| Assistant engineer | 2 |
| Assistant chemist | 1 |
| Sub Engineer | 10 |
| Dy. Supervisor | 2 |
| Time keeper | 8 |
| Senior typist | 3 |
| Typist (Grade II) and Typist (Grade III) | 5 |
| Line man | 32 |
| Pump operator | 32 |
| Senior fitter | 43 |
| Helper | 59 |
| Skilled workers | 50 |
| Semi skilled workers | 56 |
| Unskilled workers | 33 |
| Drivers | 7 |
| Attendant | 32 |
| Total | 376 |

***7.2.3 Key institutional issues concerning water supply operations in MCJ***

As is the case with many cities in India, MCJ is also plagued with issues concerning inefficiencies in service delivery and low consumer satisfaction. Moreover the existing legal and regulatory framework does not allow the corporation to work on commercial principles. It is thus essential to identify the root cause of inefficiencies in terms of the institutional issues and develop a strategy to address the same. It is also a good approach for transition to a commercial orientation of MCJ.

A SWOT approach is used for identifying the critical issues facing MCJ, both in the short term and the long term. This section aims at introducing the SWOT concept and identifying the key issues. However it is proposed that a SWOT analysis be carried out with the MCJ staff during the stakeholder consultation process/ training programmes to develop the detailed SWOT matrix.

## 7.3 Introduction to SWOT

SWOT is an acronym for Strengths, Weaknesses, Opportunities, and Threats. The SWOT analysis is an extremely useful tool for understanding and decision-making for all sorts of situations in business and organizations.

The SWOT analysis approach seeks to address the concept of strategy formulation from a two fold perspective: from an external appraisal (threats and opportunities in an environment and an internal appraisal (of strengths and weaknesses within the organization). The SWOT analysis template is normally presented as a grid shown below:

**Table 7.2** Introduction to SWOT framework

| | |
|---|---|
| **A strength**: resource or capacity organization can use effectively | **A weakness**: a limitation, fault or defect in the organicanzation that will keep it from achieving its objectives |
| **An opportunity**: any favourable situation in the organizations environment | **A threat**: any unfavourable situation in the organizations environment that is potentially damaging to its strategy |

Due to its many advantages, it is proposed to use it for the purpose of strategy formulation for Jabalpur. The detailed SWOT Analysis would be undertaken at the stakeholder's consultations. The major issues of concern have been identified to guide the discussion and brainstorming for the SWOT analysis.

### *7.3.1 Key Issues for SWOT analysis*

Key issues have been identified under various broad headings, which require immediate attention.

#### *7.3.1.1 Lack of policy guidelines for service delivery*

Currently water supply services in Jabalpur are provided as per provision of the Madhya Pradesh Municipal Corporation Act, 1956. However there is a lack of policy directive from the State Government/Municipal Government to promote managerial efficiencies and customer orientation. This further leads to a fragmented approach wherein water supply schemes are designed on an adhoc basis rather than taking a holistic approach for ensuring long terms water supply to the city

#### *7.3.1.2 Legal framework*

As per previous studies conducted by ADB, FIRE-D etc, at present there are inconsistencies in the various laws governing urban planning e.g municipal law, town and country planning law, district-planning law etc. Further the by-laws for provision of water supply need a thorough revision with clear guidelines on cost recovery and empowering MCJ to take punitive action against defaulters. New bye-laws have been proposed which take care of above concerns to an extent. These must be implemented at the earliest.

#### *7.3.1.3 Organisational structure*

There are no clear responsibilities on the role of the elected representatives and the reporting relationship between staff and elected representatives.

- The powers of mayor, mayor in council and the local body are not defined adequately.
- Further the current institutional structure of the MCJ as discussed before includes mainly engineers, some of which are on deputation from PHED to the MCJ. This arrangement needs to be clearly defined in terms of power, roles and responsibility, reporting etc.
- Within the Municipal Corporation itself, there is a clear lack of interdepartmental coordination.
- Overall there is lack of accountability and transparency. There is also a complete lack of civil society in the planning and implementation of programmes.
- The current institutional structure makes it practically impossible to have customer orientation and improved efficiencies. It is thus imperative to review the existing framework with an objective of having specialised cells for customer grievances, GIS, MIS etc.

#### *7.3.1.4 Internal Management*

One of the weaknesses of the MCJ is the complete lack of internal procedures and information management including financial management. Further the Planning capacity, human resource development and financial management functions are not adequately developed, as a result of which these are operating inefficiently. Some of the key issues of concerns are:

#### *7.3.1.5 Operational Aspects*

- There is a lack of information on consumption of water in the city, the length of the distribution network, pressure in the pipelines etc. This is due to the fact that all connections (Domestic/ Commercial/Institutional) are unmetered and the available information on the production and supply of water in the city is improperly recorded.
- The available data also is conflicting in nature and constitutes mainly of poorly recorded estimates, which could prove to be a major hindrance in the efficient planning and management of the department. The data is also inadequate to enable a good financial assessment.
- Either maps are not available or available as a sketch this kind of information is highly inadequate for carrying out GIS mapping or further planning work in this sector.

#### *7.3.1.6 Financial Aspects*

The financial data is poorly recorded. Only single digit accounting system for recording of financial information is used which does not clearly indicate the existing situation. Also, there is no monitoring and accounting of the funds allocated/ grants received and their usage. Transfer of funds from one project to the others is a common practice thus making the situation even more chaotic.

#### *7.3.1.7 Infrastructure*

- A large amount of the existing infrastructure for the operations and management of water supply is either out-lived or poorly maintained. Further there is a urgent need to modernize the infrastructure specially for data recording and transmission. There is also no policy in place for ensuring regular upgradation or replacement of old and out-dated infrastructure.
- Modernization and upgrading of systems and procedures in city management through equipment, skill-enhancement and application, and updating of manuals and codes (e.g. GIS and MIS) have not been carried out to meet the current and emerging challenges.

*7.3.1.8 Staff Capability/motivation*

- The Municipal Corporation is technically sound with a work force constituting mainly of engineers.
- Though the municipal corporation has technically competent staff, most of the staff members of the municipal corporation were found woefully unaware/lacking in modern skills for water management. Further it also lacks basic public interaction, financial management and social skills.
- Based on limited interaction with the municipal employees it can be inferred that the motivation levels and job satisfaction is very low due to the following reasons:
  - The poor working condition and multiple pressures from community, department and politicians.
  - There are no incentives for the employees to perform.
  - Political intervention in the MCJ also reduces the motivation and performance of the employees.
  - As observed during the interactions with the officers of Municipal Corporation/PHED, employees of PHED on deputation to MCJ lack a sense of belongingness as they are estranged from the PHED and MCJ treats them as outsiders being paid for by PHED. This eventually results in low motivation for performing their duties.

*7.3.1.9 Public Participation/ Consumer interface*

- One of the major issues facing MCJ right now is to improve its civil society interface and emerge as a responsible customer oriented organization. Currently MCJ is perceived as an inefficient and corrupt organization.
- Jabalpur Municipal Corporation has taken the initiative to formulate a citizen's charter. The existing citizen charter for water supply provides only a listing of services provided, the contact persons for malfunctioning services and the time lines for addressing such complaints.
- No RWAs or NGOs working in the sector of public water supply. There is a pronounced lack of role of the civil society and the urban poor in policy formulation, decision making and implementation of civic plans as the Municipal Corporation has never encouraged the participation of the public in these.
- There is a major communications gap between the MCJ and the consumers. The public has a poor image of Jabalpur Municipal Corporation due to poor service delivery. As a result, the pubic has lost faith in MCJ and have since shifted to other sources of water supply i.e. groundwater supply. This in turn increases groundwater exploitation.
- There is low level of expectation of the consumers but also low willingness to pay for piped water supply. Water is still considered as a social good and not an economic good. There is a lack of awareness about the economic costs of water. This can be attributed to low awareness among the citizens regarding the costs involved in delivery of water services.

#### *7.3.1.10 Results from SWOT analysis*

The key issues that emerged from the exercise on SWOT analysis are listed in Table 7.3.

**Table 7.3** SWOT framework

| S.No | Key issues |
|---|---|
| 1 | Political interference in technical works |
| 2 | Illegal connections |
| 3 | No or little awareness among the public |
| 4 | Low staff motivation |
| 5 | Lack of data or information for implementation |
| 6 | Base maps need to be updated |
| 7 | Poor revenue realisation |
| 8 | Lack of funds |
| 9 | Old infrastructure requiring major repairs |
| 10 | Lack of skills/knowledge among staff on latest tools and techniques for improved system management |

## 7.4 Recommendations for Policy and Institutional Reforms

Based on the critical issues identified in sections above it is proposed to initiate a comprehensive reform programme for management of water supply to Jabalpur city. The proposed strategies also aim to facilitate the implementation of the Water Demand Management Strategies proposed in the earlier chapters. Short, medium and long-term implementation goals for each of the strategies have been identified to ease the load on the Municipal Corporation for their implementation and also to provide the Municipal Corporations with measurable targets.

The key underlying principles that have been adopted while formulation of the strategies are:

- Promoting a commercial incentive based environment for water supply, based on cost recovery principles while ensuing services to the poor.
- Greater public participation and involvement of public in managing water supply systems.
- Enhanced capacities of the Municipal Corporation to manage the reform programme.
- Reorientation of the utility to have a customer focus facilitating improvements in service delivery.

To achieve the above objective following reform strategies are proposed:

### *7.4.1 Formulation of a vision and policy for provision of water supply services*

To achieve the objectives it is recommended that MCJ sets out a vision for itself, which should incorporate the principles stated above, and act as a guiding document for the water utility. As of now there is no policy or vision document for provision of water supply services to Jabalpur. As a first step it is thus recommended that a vision be developed for provision of water supply services by involving all stakeholders such as MCJ employees, NGOs, academia, RWAs etc. The vision statement should draw upon the existing national and state water polices and urban development plans adopted by the state and national governments and also the expectations of the consumers.

The policy should address issues such as consumer awareness, up gradation of infrastructure, reducing losses/NRW, cost recovery and financial sustainability of operations, improved service delivery and customer satisfaction. It is also recommended to have a legislation in place which could address the issue of over exploitation of groundwater and its recharging.

#### *7.4.1.1. Defining a water services policy and vision for MCJ*

The present study is instrumental in identifying some of the key issues plaguing the Jabalpur Municipal Corporation. On the basis of this analysis it is proposed that a brainstorming session be conducted to develop a vision for water supply in the city. It is important to involve the stakeholders in the process right from the start process.

The current citizen charter of MCJ for provision of water supply services provides only a listing of services and the suggested time frames for action. This needs to be revised and a much more comprehensive charter including the vision for MCJ, details on the various services provided by MCJ and the mechanisms for availing those services should be developed.

#### *7.4.1.2 Infrastructure development plan for water supply*

On the basis of the vision document MCJ should develop a master plan for provision of water supply services in Jabalpur. It may also draw-up annual plans and short-term plans for a period of 5 years focusing the areas identified in the city level master plan and policy as needing immediate attention. It is important to understand here that such plans are instrumental in the implementation of the water policy and thus should have clearly defined targets. The plans should also outline the approach that should be used for achieving these targets, the possible constraints as well as suggest methods to overcome these constraints. It would be highly beneficial in the implementation and monitoring of the annual plans if it incorporates an activity schedule on a time scale.

### *7.4.2 Organizational restructuring*

As discussed in sections above, the Municipal Corporation of Jabalpur is responsible for provision of water supply services in Jabalpur in line with the provisions of the Madhya Pradesh Municipal Corporations Act 1956. MCJ provides water supply services through the water works department, which is primarily staffed with engineers some of which are on deputation from the Public Health Engineering Department. Further there is an ambiguity in the roles of various departments. Following broad recommendations are suggested for consideration by MCJ for improved service delivery. Each of these would require brainstorming and stakeholder consultations to develop further.

1. Restructuring of the water works department with clear demarcations for planning, construction, design, distribution O&M and plant O&M.
2. Reorganization of the institutional structure in parallel with the proposed reorientation of the distribution network into hydraulically discrete zones such that each function is taken care by one engineer.
3. In addition it is important to clearly define roles for each functionary in the demand management strategy and provide adequate training to carry out the desired tasks.
4. Further it is important to build in an incentive scheme for the employees to motivate them to achieve improved efficiency.

5. Certain engineering posts may be re-designated as managerial posts in wake of the responsibility to be assumed by these professionals after the reforms.
6. Creating special cells for functions, which have been neglected till date such as leak detection, consumer grievances and database management. This has been discussed in detail below:

#### *7.4.2.1 GIS cell*

The Municipal Corporation has a computer wing. To set up the computer/GIS cell, the services of the computer cell could be used. The computers and the software could be purchased and installed by this wing. Hiring of specialized manpower for preparation and updation of GIS maps needs to be undertaken.

#### *7.4.2.2 Consumer grievance cell*

The consumer grievance cell needs to be created for registering consumer complaints, sort them according to the action that is required and hand it over to the concerned personnel. The short-term measure for consumer grievance cell calls for a minimum facility of telephonic registration of complaints besides the existing system of personal complaint registration. The possibility of involving the private sector can be explored for this cell. It is expected to maintain a complete database on the type of complaint, area/ward/zone from which the complaint is registered, concerned personnel/ department and also a follow up on the action taken.

#### *7.4.2.3 Leak detection*

The leak detection cell is proposed to be set up, first to enhance the leak detection facilities of the water department, second to draw attention to the problem of leakage in the system and ultimately to delegate manpower which looks after only the leak detection and leak repairing functions. It is proposed at the short-term level to outsource this function to a private player till the time capacities of the MCJ are built to handle it on its own. The private sector involvement could be based on an incentive based approach, where incentives could be provided to the private body for attending above a certain number of complaints on a daily basis.

#### *7.4.2.4 Billing and collection*

The aim of setting up a separate cell for billing and collection is to segregate this function from the rest of the water department functions. The short-term aim for this cell is to have completely computerized records and the analysis of the available information. It is also proposed to decentralize this process to the zonal levels for ease in billing and collection.

As a first step towards increasing the bill collection efficiency, it is proposed to club the water bill with the electricity bill. The electricity department has better capacities for handling bill collection. This system is practiced in Chandigarh and has been quite successful. The possibility of commission-based outsourcing can also be considered for bill collection.

### *7.4.3 Legislation for control on groundwater use*

It has been observed that the Jabalpur municipal corporation is not very comfortable with the idea of bring in substantial changes in the existing tariff structure. This is partially because of the apprehension that such a strategy may lead to a reduction in their consumer base, especially with the consumers (mainly bulk consumers) increasing their reliance on groundwater supplies. It is therefore necessary that legislation should be formulated in the state so as to regulate and control the development of groundwater resources. This may include providing permission for sinking new wells and registering the existing users, especially in sensitive areas wherein unsustainable withdrawls have been observed. Delhi Government has a similar legislation

Model Bill circulated by the Union Ministry of Water Resources has underlined the broader issue of regulation and control of development of the groundwater in the country. The Model Bill provides for an independent regime for this purpose obviously looking at the geographical size of the States and multiple problems of regulation and development of groundwater in urban and rural areas of these States. In line with this, Delhi Water Board (Amendment) Bill was introduced in 2002.

Similarly, legislation for harvesting rainwater in the state should be developed. Different states have already enacted such legislation or are in the process of doing the same. The Central Ground Water Authority (CGWA) has made rainwater harvesting mandatory in all institutions and residential colonies in notified areas (South and southwest Delhi and adjoining areas like Faridabad, Gurgaon and Ghaziabad). This is also applicable to all the buildings in notified areas that have tubewells.

Such legislations will not only check the misuse and over use of resources but shall also bring in awareness on the need to conserve resources, especially rain water.

#### *7.4.4 Management information system (MIS)*

It has been observed in the Jabalpur Municipal Corporation that important information is usually scattered, non-standardized, and improperly reported. An MIS (management information system) can help public managers achieve greater efficiency and effectiveness, especially when there are resource constraints. It is a tool that can be useful in making all types of decisions – at the operational, strategic, and policy levels.

One of the most critical bottlenecks in implementing the water demand management strategy is the lack of baseline information/ unavailability of authentic information even with the middle/junior management level. Thus it is recommended that as a first step to the reform process MCJ should develop a comprehensive MIS that covers all aspects of water management.

An MIS is basically a system for recording and reporting information in a way that promotes efficiency and effectiveness, and facilitates long-term planning and decision-making. Hence, information has to be presented in such a manner that is useful for decision-making instead of remaining just as data, which may not serve the needs of the corporation.

**Box 7.2** Bangalore Information System on Networks (BISON)

Bangalore Water Supply and Sewerage Board (BWSSB) has recently completed the development of a Geographic Information System (GIS) and computerization of water supply and sewerage networks for 100 sq.km. of its service area in Bangalore. The project was implemented with a funding of 7.8 million francs from the Govt. of France. The consultancy services for the Project were provided by SCE (Nantes, France) and IRAM Consult (New Delhi, India). After the successful completion of the Phase-1 of the GIS development for the 100 sq.km. pilot zone, the Project has been extended, with additional French assistance of 5 million francs, to cover the full BWSSB service area of 300 sq.km. in Bangalore. BWSSB plans to ultimately implement a GIS based system for about 600 sq.km. covering the total Bangalore Metropolitan area and some other areas.

**Source:** *Change Management Times*, September 2003 by Abdullah Khan, President, IRAM Consult Intl. Pvt Ltd., New Delhi

An MIS can thus help the municipal corporation to achieve greater efficiency and effectiveness, especially when there are resource constraints (Box 7.2). The approach to develop a structured MIS is presented here. The key features of the approach are:

– Information collection and compilation: Data is captured at the operational level viz. Accounts, Finance, Field Units, site offices, etc. in standardized formats. Thus, it constitutes a major part of the short-term strategy proposed for MCJ. A key part of the process is to identify the right kind of information required at each level and then develop indicators to capture the required information.

– Information Technology (IT) infrastructure- It forms the backbone of the system and facilitates timely & accurate collection/compilation and analysis of data.

– Performance Measurement: At the middle level and top level, the information is validated, reviewed and corrective action initiated. Performance measurement is undertaken at this level to optimally judge the performance of the Municipal Corporation and its employees.

***Short and Medium term Strategy***

As a first step to establishment of a computerized information management system in MCJ, it is imperative to undertake a detailed assessment of information requirements for decision-making process. This may be compiled in the form of performance indicators to be used at all levels. Formats for collecting the relevant information to feed into the indicator framework may subsequently be developed along with the frequency of reporting.

The information to be collected may broadly be divided into three sets (refer GIS Strategies, in Chapter 5) as indicated in the strategy for developing a GIS database:

- Asset database
- Operational data
- Consumer data

***7.4.4.2 Long term interventions***

All departments of MCJ should be technologically linked (LAN, WAN etc) so that communication and flow of information is instant and smooth. All the information can be added in the GIS database in due course. Such exercise shall also help MCJ to make an analysis of its performance compared to the targets set for it on national and international benchmarks.

***7.4.4.3 Operationalizing performance measurement***

Operationalizing a performance measurement system would essentially involve developing a set of performance indicators to imitate the benchmarking process, developing an MIS to collect the right information and start using the information generated to take corrective action for improving the performance of the utility in both physical and financial terms. Figure 7.4 gives a broad outline of procedure for operationalizing a PM system.

***7.4.5 Performance measurement (PM)***

Though water supply projects are designed as per the Government norms there are hardly any performance targets that the municipal corporation adheres to. Further, there is no assessment of the service delivery levels and conformity to norms. There is thus no obligation of the municipal corporation to check the service levels as envisaged are achieved on a continuous basis. To achieve the desired efficiency levels it is thus critical to define operational targets for both physical and financial performance. Performance measurement is the starting point for any such initiative. A properly designed PM system, in conjunction with a supporting MIS (Management Information System), can go a long way in improving the efficiency and effectiveness of the MCJ. A simple truth about PM is that 'what gets measured gets done'.

Performance Measurement is a practice that many organizations adopt in order to achieve higher levels of efficiency and greater effectiveness in their operations. It also serves as a tool for strategic decision-making and long-range planning. With increasing pressure on urban local bodies to improve their performance in the provision of civic services, there is a great need to integrate modern management practices into public systems, drawing from the corporate sector. In the context of urban local bodies, PM can be defined as the process of determining how efficiently and effectively the concerned agencies are delivering the services. It provides an assessment of the quality of work the local body is doing and how successful it has been in satisfying community needs and expectations.

**Process for implementing performance measurement system**

| Steps | Actions | Responsibility |
| --- | --- | --- |
| Step 1<br>Commit to measuring performance | • Commit at the highest level<br>• Create awareness<br>• Allocate resources<br>• Establish a working group | • Chief officers<br>• Head of departments<br>• Officers and supervosors |
| Step 2<br>State goals and objective | • Define goals<br>• Formulate objectives<br>• Prepare a formal statement | • Chief officers<br>• Head of departments<br>• Invited experts and community representatives |
| Step 3<br>Identify key performance measures | • Capture important dimensions<br>• Relate to objectives<br>• Focus on efficiency and outcomes | • PM task force<br>• Officers and supervisors of concerned departments<br>• Consultants/advisers |
| Step 4<br>Develop performance indicators | • Ensure that indicators are measureable<br>• Make them easy to understand and implement<br>• Ensure that are niether too few nor too many<br>• Involve employees and service recipients | • PM task force<br>• Officers and supervisors of concerned departments<br>• Community representatives<br>• Consultants/advisers |
| Step 5<br>Create a system for collecting performance information | • Assign responsibility to staff<br>• Standardize procedures<br>• Create an MIS cell<br>• Integrate PM with MIS | • Task force<br>• Analyst (statistics)<br>• MIS specialist<br>• Consultant |
| Step 6<br>Analyse performance | • Compare findings to benchmarks<br>• Draw conclusions<br>• Prepare performance reports | • PM task force<br>• Department officers |
| Step 7<br>Use performance information | • Discuss result with service units<br>• Inform the citizens<br>• Reward good performance | • Commissioner<br>• Head of Departments<br>• Task force coordinator<br>• Consultants/advisers |

PM – Performance Measurement; MIS – Management Information System

**Source:** TERI 2004; Benchmarking performance: A manual on performance measurement in Urban Local Bodies

**Figure 7.4** Implementing PM system

The most important reasons for measuring performance in urban local bodies are:

- Greater transparency in the organization
- Strengthening accountability
- Rationalizing decision-making

PMS can also assist in the performance appraisal of employees by providing the basis for decisions regarding annual salary increments and promotions or even punitive action against employees whose performance is unsatisfactory. This, in turn, would lead to better governance.

The key elements of a PMS are a PM (performance measurement) framework, a set of performance indicators, a supporting MIS (management information system), and a strategy for performance benchmarking.

#### *7.4.5.1 Performance measurement framework*

Performance measures indicate how much or how well the Corporation is doing. An I-O-E-O (Input-Output-Efficiency- Outcome) framework can be used to measure the performance of a utility against four types of performance measures.

- Input measures indicate the amount of resources used. These indicate the level of effort but are strictly not a measure of performance.
- Output measures indicate the level of services provided or amount of work done. These measure performance in terms of how much, not how well or how efficiently.
- Efficiency measures relate outputs to inputs, or work performed to the resources required to perform it. These indicators are central to PM, but they do not measure the results achieved.
- Outcome measures indicate the degree to which programme objectives are achieved and measure the value of service from the perspective of the end-user.

#### *7.4.5.2 Performance Indicators*

In practice, measuring performance is a complex exercise because, for each selected measure, there should be a practical measurement strategy – an indicator that captures the concept to be measured and is easy to operationalize with the available information. Table 7.4 below gives an example of I-O-E-O indicators.

**Table 7.4** Examples of four types of performance indicators applied to urban water supply service

| Type of Measure | Water Supply Service |
|---|---|
| Input | Installed capacity of water filtration and treatment plants |
| Output | Average daily clear water production |
| Efficiency | Total staff per 1000 connections / % water losses |
| Outcome | Percentage of population receiving adequate quantity |

### *7.4.6 Capacity building*

To effectively implement a comprehensive and integrated water supply reform programme there is a need to build the capacities among the staff of the municipal corporation on the latest tools and approaches to managing a water supply utility in an efficient manner. There is severe need to build capacities of the staff and the officials on key concepts of the WDM strategy, policy, and institutional frameworks to cover issues related to demand forecasting, auditing, commercial management practices etc. A continuous process of training the professionals on diverse issues is required. This will not only improve their skill set but also motivate the staff.

Some of the specific aspects on which the municipal staff would need training are project formulation and appraisals, financial management, social aspects, GIS, MIS and modern tools for water management such as network modelling, leak detection and SCADA systems. In addition almost the entire staff (supervisory and managerial) needs to be trained on the use of Information technology. Box 7.3 highlights the human resource development efforts undertaken at the Chennai Metro-water which may be used as an example for MCJ.

**Box 7.3** Human Resource Development, Chennai

Chennai Metro water as a part of Human Resource Development has established a full-fledged staff-training centre as early as 1979 to cater to the growing needs of all categories of employees. Metro water Training Centre has been imparting training to its staff covering all the categories including field workers. For about two decades the orientation was mainly in the direction of improving the operational practices. A reorientation towards managerial aspects was considered necessary and accordingly the staff training activities were restructured.

**In-House Training Program for Metro Water Staff**

Employees including technical, administrative, finance and field workers are trained in courses related to Finance, Commerce, Administration, Engineering and Operation. Twenty-eight modules in two categories Technical and Management are offered. New topics such as leakage control, water conservation, water quality, human resource development, project management and financial management have been introduced. Special courses are also offered in Introduction to computers, Implementation of Official Language to familiarise the staff in preparing drafts and letters in Tamil, wireless operations, Proper Maintenance of Files and Records, Contract procedures and Transparency Act, Activity Based Accounts and Budgeting.

**Training Program for Other Institutions**

Exclusive courses are also conducted based on request from various institutions. Training programmed for Science students of Women Christian College, Chennai was conducted in "Water and Sewerage Treatment and Analysis". An "Orientation Course on Execution of Sewerage works" for TWAD Board Engineers and Tamil Nadu Urban Development Project sponsored Orientation Course for Municipal Engineers was designed and conducted for 249 Municipal Engineers. Government of India (CPHEEO) sponsored refresher courses are conducted every year. Awareness programme on Rain Water Harvesting are conducted for board staff, NGOs and general public.

The board officers are deputed to attend seminars and training programmes conducted by other organisations in India and abroad. Employees are also encouraged to pursue graduate or postgraduate programmes. As a part of the human resource development, department tests, appreciation and awards, are also extended to achieve increased productivity and efficiency for organisational success. The participants of other public utilities from all over India are participating and getting trained from the level of Assistant / Junior Engineer to Superintending Engineer cadre in these courses.

The topics covered in Metro Water Training Centre are:

1. Sewage Works Supervisors
2. Care and Use of Chlorinators
3. Corrosion Control
4. Filter Operations
5. Laying of Water Mains and Sewer Mains

#### *7.4.6.1 Implementation plan*

In light of the above and the skill enhancement, it is recommended that a structured approach be developed for capacity building. Following specific actions need to be undertaken:

- A separate training cell needs to be created to look into the training needs for the entire water works department of the municipal corporation. Outsourcing of this cell to a specialised external agency may also be considered.
- The training cell would identify the specific training needs of all employees and develop a training calendar for a year.
- Specifically targeted training programmes may then be conducted using both internal and external resources.
- A feedback and evaluation system must also be instituted to monitor the effectiveness of the training programmes.

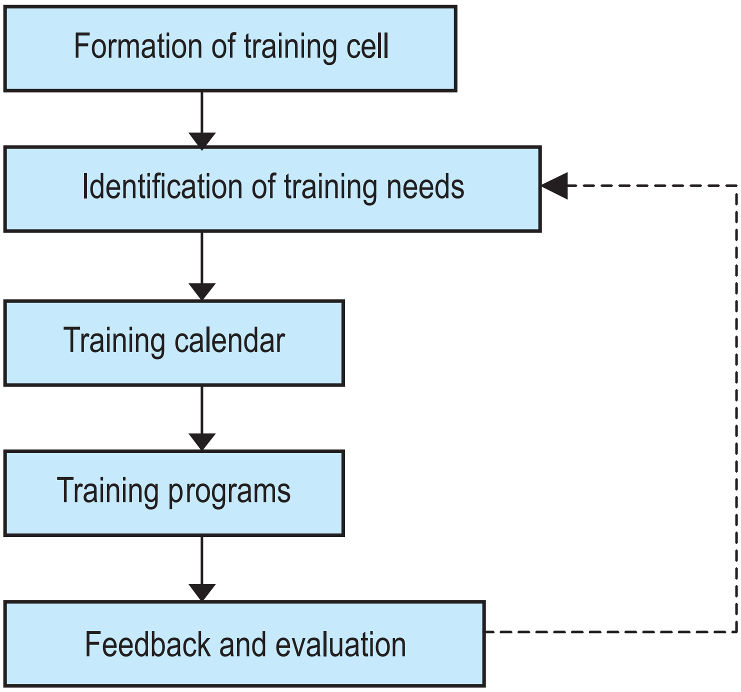



**Figure 7.5** Capacity building framework

To enhance the current skill set of functionaries and to enable them to perform the envisaged tasks more efficiently, the following measures are recommended:

1. It is recommended that for the purpose of training, the entire staff may be divided into four categories:
   - Operating level: Beldars, foreman, lineman etc.
   - Supervisory level: JEs
   - Managerial level: AEs and above who have overall responsibility for management within their zones.
   - Top management: Superintending/Chief engineers, Commissioners, elected representatives (councillors, mayor in council, mayor etc).

2. Following training modules are proposed as part of the capacity building programme:

   - Policy and institutional reforms
   - Technical
   - Financial management

3. IT (Information technology)

   - Environmental management
   - Social
   - Customer services
   - General like safety procedure, regulations etc.

A combination of various training tools such as classrooms, case studies, hands on training and cross visits may be employed for each course. The training cell should also work out the training methodology for each program while designing the courses. A broad outline of training methodology it is given in section below:

#### *7.4.6.2 Training methodology*

It is proposed that a combination of lectures, exposure visits and onsite training may be employed for skill development of the staff. To begin with the training cell must conduct a review of the functions and responsibility of the entire staff of MCJ and draw up the list of skill sets required for undertaking the job. This may then be compared to the existing skill sets of the various functionaries to identify the specific training needs.

As a first step the top management of MCJ must be sensitised to the reform agenda and need/ benefits of investing in a large-scale capacity building program.

Specific courses as given in Table 7.5 may subsequently be conducted.

**Table 7.5** Training modules

| Level → / Module ↓ | Operating level | Supervisory level | Managerial level |
|---|---|---|---|
| Policy and institutional | | | – Policy and institutional frameworks for delivery of WATSAN services including various forms of PPP's.<br>– Principles of Financial Management including tariff restructuring<br>– Project formulation and appraisal |
| Technical | – O&M of WTPs and distribution network<br>– Leakage detection and control<br>– Record keeping<br>– Metering | – Overview of water supply<br>– Basics of design<br>– Basics of equipment O&M<br>– Water balance estimation and auditing.<br>– Materials management | – Overview of water supply operations.<br>– Importance/concepts of WDM<br>– Tendering for technical works<br>– Preparation of DPRs (project formulation and appraisal)<br>– Project planning and control (Use of PERT/CPM) |
| Financial management | – NA | – Basics of financial management<br>– Accounting systems<br>– Procurement | – Basics of financial management<br>– Accounting system<br>– Budgeting<br>– Principles of tariff restructuring |
| IT (Information technology) | – Basics of computers (wherever applicable) | – Basics of computers<br>– MS–Office<br>– Database management | – Basics of computers<br>– MS–Office<br>– Database management including GIS<br>– Modeling tools for distribution optimisation and demand assessment<br>– Management information systems |
| Environmental management | – Environmental issues related to water supply | – Environmental issues related to water supply.<br>– Basic course in environmental assessment | – Environmental issues related to water supply<br>– Basic course in environmental assessment<br>– Techniques/tools for environmental assessment |
| Social | – Social issues related to water supply | – Social issues related to water supply | – Social issues related to water supply<br>– Rehabilitation of PAP<br>– Techniques for social assessment |
| Customer services | – Basics of public dealings | – Grievance redressal system<br>– Basics of public dealings | – Grievance redressal system<br>– Basics of public dealings |
| General | – Safety procedures<br>– Rules/regulations governing MCJ | – Safety procedures<br>– Rules/regulations governing MCJ<br>– Time management | – Safety procedures<br>– Rules/regulations governing MCJ<br>– Time management<br>– Human resources management<br>– Basics of water resource management and issues facing water sector in India |

### *7.4.7 Regularisation of illegal connections*

Non-revenue water in Jabalpur has been estimated to be around 40%. A major part of the non-physical losses are attributed to pilferage/illegal connections across the city. All unauthorized usage through either tampering of meters, illegal withdrawal from mains/distribution pipes etc is considered as illegal connection. Illegal connections not only result in a loss of revenue to the municipal corporation but also lead to wastage of water, as these consumers do not value the water they use. Further, illegal withdrawal of water is against the basic principles of law and equity. Thus, a strategy for reducing the number of illegal connections needs to be formulated and adopted.

The Nagpur Municipal Corporation has adopted a pragmatic approach to the regularization of illegal connections and a similar approach may be tried for Jabalpur (refer Box 7.4). As part of its efforts to reduce revenue loss, the Bangalore Water Supply and Sewerage Board "regularized" 35,000 unauthorized water connections during the past six years and replaced 1.35 lakh outdated or malfunctioning domestic water meters (refer Box 7.5). (www.hinduonnet.com)

**Box 7.4** Strategy adopted by Nagpur Municipal Corporation for Reducing Unaccounted-for Water

In early 2001, the water supply situation in Nagpur city was far from satisfactory. Nagpur Municipal Corporation (NMC) was concerned about a very large number of illegal (unauthorized) connections that resulted in substantial loss of revenue to the corporation. Although all water connections in Nagpur city were required to be metered, it was estimated that there were nearly 35000 un-authorized water connections in Nagpur city at that time.

In order to improve the revenue situation NMC declared a time bound scheme for regularization of all illegal water connections in the city. To implement the scheme NMC adopted a pragmatic approach, since water connections (both legal & illegal) were installed through plumbers, NMC decided to involve plumbers in detection of illegal connection and its subsequent transfer into legal.

A security deposit of Rs 5000 was announced for licensed plumbers and the renewal fee was increased from Rs.25 to Rs. 30. After a protest by plumbers, it was agreed upon that the security deposit would be waived off against an active participation by plumbers towards the drive to detect and regularize illegal connection. A target of finding 35000 illegal connections was set with an incentive of Rs. 50-100 per illegal connection.

The plumbers were organized into small teams, which conducted door-door survey, filled simplified forms and collected charges as laid down by the NMC. Effective arrangements were made, to accept application forms, sanction application, and accept requisite charges. Awareness was disseminated through media about the drive.

About 25,000 (71%) illegal connections were detected and regularized within a period of 4 months. Revenue from water supply of the NMC also had substantial increase. The quantity of water billed in 1998-99 was 163 MLD, whereas in 2002-03 the quantity billed was 300 MLD, i.e., nearly double.

This initiative has brought the NMC closer to its goal of universal metering in the city. The time-bound regularization scheme received tremendous response due to the simplified procedures and reasonable charges. The citizen's feedback as reported in the media was very positive.

**Box 7.5** Legalizing water in slum colonies – Bangalore

The BWSSB (Bangalore Water Supply and Sewerage Board) created a social development unit within the utility to promote legal connections to the piped municipal water supply as part of a much larger water sector reform strategy funded by the Australian aid agency, AusAid. Although the unit was created specifically to drive a donor-funded pilot project in three slums, it has persisted beyond the end of the pilot, expanded its scope to a handful of new slums, started planning for the entire city, and continued to generate great support from the Chairman of the Water Board. These efforts provide an interesting case of how a progressive unit within a reform minded organization can tackle the twin problems of low access levels and illegal connections in slums.

When the social development unit embarked on its first effort to connect slums legally to its piped network, it was clearly operating at the level and mindset of a pilot project. The project had all the requisite nursing required to ensure its success. Three slums were carefully chosen to reflect typical slum characteristics across the city: high density, legal land tenure, and informal land tenure. The aim of the project was always to show that slums can be connected with slum dwellers paying some share of the cost. To this end, several measures were taken to lower the bar and ensure replicability. First, the water board abolished the requirement for proof of formal land tenure. Second, pricing was subsidized through a reduced connection fee, although the volumetric tariff rate applicable citywide was not altered. Third, an institutional structure was developed in which geographically situated sub-district engineers work closely with the head of the newly created social development unit to extend the pipes, ensure water flow, maintain pressure, and carry out water meter readings. Fourth, the board gained bargaining power and leverage with slum dwellers after an amendment to its charter was passed making illegal connections punishable by fine and imprisonment and the board embarked on a controversial regularization drive.

Roughly 1,000 households were connected in the three pilot slums, though it is only a very small proportion so far, the approach will over time be more than a mere policy gesture. The case is thus a good example of how a public sector utility begins to meet its obligations to serve the entire city, including slum dwellers.

#### *7.4.7.1 Implementation plan*

***Short term***

It is generally not practical to simply disconnect illegal connections and therefore, it is recommended that such connections be legalised by charging a nominal fee. Strategy for reduction in illegal withdrawal would essentially involve development of a policy for regularisation of illegal connections and a strict enforcement of the same. The strategy should aim at regularising maximum number of illegal connections through a simple administrative procedure. A step-by-step approach to regularisation of illegal connections is discussed below:

- *Identification of illegal connections*: The first step would be to identify and record information on the number of illegal connections, their location and population/households served. A detailed survey may be commissioned for this purpose. One approach could be to outsource this activity to the local plumbers on an incentive based approach. These plumbers would be more aware of the location of such connections. These local plumbers can also convince people about the need for regularization and the scheme offered by MCJ.
- *Setting date for regularization of illegal connections:* The entire regularization should be within a specified time frame. After lapse of this date, a strict enforcement campaign should be launched to disconnect all illegal connections or regularize them only after a penalty fees is deposited.

- *Awareness campaign:* An awareness campaign must precede any such initiative, which should include the use of both PLA (Participatory learning appraisals) tools and mass media to create awareness among the consumers about the problems stemming from illegal withdrawal of water. The awareness campaign must also involve the local councillors and the RWAs. Incentives, in the form of financial awards and recognition, may be instituted for wards with no illegal connections. This shall encourage the councillors to play an active role in the regularization drive.
- *Regularization of connections:* Detailed formats and guidelines should be developed, discussed and disseminated before a regularization drive is initiated. Connections may be regularized by paying a nominal fees, which may be same, or 1.5 times the charges for a new connection. It is very important that all necessary information is provided to the public regarding the regularization policy and the procedures should be simple so as to encourage people to regularize connections.
- *Provision of adequate and safe dirking water:* In most cases the community resorts to illegal connections when adequate water supply is not available. It is thus ensured that all areas with major concentration of illegal connections are provided with adequate water supply through augmentation of the network.

***Medium term***

In the medium term, a strict enforcement on part of MCJ is a must. The users should realize the economic cost of water and start developing a habit to pay for the water consumed by them. The municipal corporation needs to take punitive actions for those indulging in any kind of water theft, on lines similar to the electricity sector. Lessons may be drawn from the electricity sector in this aspect.

***Obstacles***

Political support and community awareness are key to success of any such drive. Further simple procedures and transparency would ensure that more people come forward for regularization of connections.

### *7.4.7 Consumer awareness*

One of the key challenges facing MCJ is the low level of satisfaction amongst the consumers regarding the services provided by MCJ. It has also been observed that water is considered more as a social good rather than an economic good. Awareness on water conservation is also minimal. Such a scenario leads to water wastages, low willingness to pay and a poor perception of service provider, which further leads to a communication gap between the consumers and the corporation as the feedback mechanism is completely absent. It is therefore necessary to build consumer awareness on water use and conservation. Enhanced consumer awareness shall also help MCJ in getting greater co-operation from the consumer and build a better understanding of their needs.

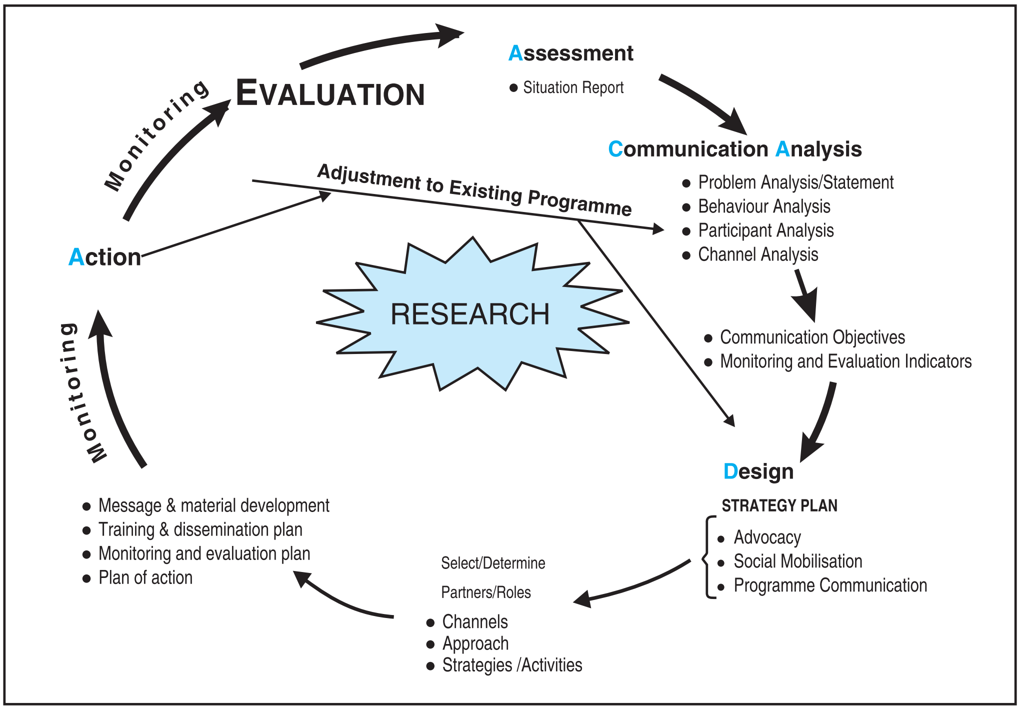
Education and the involvement of the general consumer is also an important aspect of any WDM strategy. To tackle the above issues, it is imperative that the reform programme includes a component of IEC (Information, Education and Communication), which would motivate users to conserve water. This shall also build awareness on the costs borne by MCJ in water treatment and supply to household and hence create a willingness to pay among consumers. It may further be necessary to build a consensus among the various stakeholders on the reform programme that MCJ may embark upon. It is thus essential to involve stakeholders such as academia, resident welfare associations, prominent NGOs and independent experts in the project preparation and build consensus on the reform agenda. Media should also be included extensively in such a process of consensus building.

A well-designed IEC campaign should thus be launched which aims at delivering certain key messages to the consumers such as:

- Key issues plaguing water supply services and the need for reforms
- Water stress in the country and the need for conservation
- Rainwater harvesting: Need and approach
- Need to pay for water
- Need for metering and the procedures involved
- Regularization of connections
- Water conservation at household level
- Avoiding water leakages before and after the property line etc.

***IEC strategy***

The IEC strategy should necessary look at informing various sets of consumers and bringing about a behavioral change towards water demand management. Figure 7.6 gives a framework for an IEC strategy for water demand management.




**Source:** UNICEF 2004

**Figure 7.6** Framework for IEC strategy

### *7.4.7.2 Approach to IEC campaign*

It is suggested that a step-by-step approach to IEC may be followed as given below:

- **Step1**: Inform and build consensus among the MCJ employees on the need for reforms and take feedback.
- **Step2**: Identify and map various stakeholders such as RWAs, NGOs, academia, researchers, media etc and inform about the program through workshops/stakeholder consultations.

- **Step3**: Modify the strategy incorporating the suggestions received in Step 1 and 2.
- **Step 4**: Design IEC campaign for general public. It is suggested that a two-pronged approach is adopted for such a campaign involving the use of mass media tools on one hand and a direct interaction with the community groups through involvement of NGOs to inform the community on various aspects of WDM. Exhibitions, documentaries, pamphlets, banners etc may also be developed for IEC. In addition it is also recommended that RWAs and municipal councilors be motivated to act as ambassadors for WDM.
- **Step 5**: Roll out IEC campaign in a phased manner.

### *Obstacles in implementation*

Current levels of awareness on the subject are minimal. This may pose problems in selecting the most appropriate media for dissemination of information. Bringing different stakeholders on a common platform will also be challenging assignment.

## *7.4.8 Regulation*

It is proposed that in the long run MCJ may consider separating the policy formulation, regulatory and service provision functions. An independent regulatory body for setting up of tariffs and ensuring service levels has successfully been used in other infrastructure sectors and it may be worth exploring the possibility of an independent regulator at state level (Box 7.6) for this purpose. However a detailed feasibility of any such initiative needs to be carried out. The section below brings out the possible role for a regulator and the key features of the same.

### *7.4.8.1 Functions of a regulator*

The existing water department is highly monopolistic in nature with no competition from any private player in the sector and having the sole responsibility for providing safe drinking water in the city. In such a circumstance, the regulatory authority is expected to have the following functions. These functions could evolve over the path of transition of the economy from state of control to liberalized competition. Its core functions should include:

- Price Control
- Promotion of Operating efficiency
- Service standard specification and monitoring
- Control of externalities
- Maintenance of public good functions
- Ensure asset serviceability over time
- Ensure development of essential infrastructure
- Control over powers to manipulate land values/ land speculation
- Controls over unfair trading practices
- Safety net regulations
- Promote water use efficiency
- Ensure responsiveness to final customer needs

**Box: 7.6** Setting up of Maharashtra Water Regulatory Commission

Based on the recommendations of the Sukthankar Committee, a Maharashtra Water and Waste Water Regulatory Commission (MWRC) has been established. The key functions of the Maharashtra Water Regulatory Commission (MWRC) would be the following:

– Regulation of the quality of service being provided by local bodies and to be provided by the licensed entities.

– Economic regulation of tariffs to be charged by the service providers (local bodies, CWSEs, other service agencies such as MIDC, MJP, City and Industrial Corporation, and private sector entities).

– Issue and regulation of licenses to the proposed CWSEs, in association with one or more local bodies or other agencies such as the MJP and the MIDC. The MWRC will issue licenses to all new entrants, including private operators, in the sector after following a transparent procedure.

– Coordination with other regulators for environmental regulation, especially related to drinking water quality and wastewater disposal standards.

– Collection and dissemination of sector information to enable the MWRC to establish good regulations and to assist different interest groups, especially consumer councils, to recognize improprieties by the local water supply entities.

Regulation related to tariff setting are as follows –

- Tariff setting should ensure a fair charge to customers in relation to services consumed and the commercial viability of the providers.
- The MWRC should establish mandatory guidelines and principles, such as recovering costs for desired service levels, to help tariffs gradually move toward this goal. It should conduct regular reviews of the tariffs set by local bodies and over time as more information becomes available it should develop yardsticks to measure progress.

To make the new regulation and tariff setting more responsive to community needs and willingness, the new entity should initiate a process for effective community participation.

1. The MWRC is proposed to set up or strengthen consumer councils that can articulate consumer demands and preferences and provide them capacity building support.
2. The MWRC is also proposed to set up an effective public consultation process for licensing and tariff determination. To be meaningful, such consultation must be backed up by timely provision of relevant information to the public about existing service levels, financial investments and expenses, hidden subsidy transfers, etc.

Its advisory role should include providing information to the Government and advising the Ministries on issues of importance or whenever the regulator's advice is requested.

The role of a regulator is bound to change once the sector, or various segments in the sector, undergoes changes from a monopolistic to a competitive structure. For example, in a competitive market, the tariff setting function of a regulator may become 'light' or be 'forbearing'. Thus, there is a need to delineate the regulator's role given the degree of competitiveness in the sector.

#### *7.4.8.2 Other salient features*

The following principles need to be kept in mind while designing the regulatory framework, to ensure regulatory independence and to balance the interests of various stakeholders:

- Autonomy of the regulator
- Transparency and encouraging stakeholder involvement
- Predictability through well defined criteria for decision making and review of standards
- Flexibility by being open to alternative regulatory tools
- Consultative through consultation with all stakeholders for encouraging commitment and a better understanding of the implications of the proposed action
- Independence through representatives from the private industry and academic or research institutions along with Judge of High Court or Member UPSC in the Selection Committee, setting up of a Regulatory Commission Fund funded by grants/ loans by Govt., levy of fees on the licensees
- Accountability through independent review and assessment of the regulatory body against the specific objectives and an appeal mechanism in relation to the regulatory decisions

Box 7.6 describes the Maharashtra Water Regulatory Commission, which has recently been established and is also the first regulator set-up in the water sector in India. Thus, it can be taken as a model for setting up a water regulator in Madhya Pradesh. It is important to mention here that a regulator is not feasible to be set-up at the city level. It is thus proposed that a detailed survey of the water sector in the State is undertaken before a decision on the type of regulator as well as the exact functions and features of a regulator are defined.

#### *7.4.9 Public-private partnership arrangements*

Public-Private Partnership is widely looked upon as a solution to the failure of publicly owned and managed utilities. It is important, however, to understand that private sector involvement cannot of itself and by itself remove many of the barriers to efficiency, which impedes public sector operations. The scope of private participation to yield performance improvements will partly depend upon the way the Municipal Corporation is functioning presently. Also, the following four interrelated factors play an important role in the achievements made by the private players:

- The form of private involvement (Table 7.6 gives the details of the available models of Public-Private Partnerships).
- The type of private company involved- this includes its technical and managerial competence, the range of its operations etc.
- The post-privatization regulatory regime- this would include all the continuing roles of the public sector and the institutions (contracts, regulatory agencies, laws, market tools etc.) employed to influence, provide incentives for or to directly control private sector behaviour.

It is however important to note that the involvement of private sector in the water sector is an exceptionally difficult tasks. The following characteristics of the water sector make the involvement of the private companies a particularly challenging venture:

- The level of natural monopoly and the lack of substitute products
- The public and merit goods supplied by the sector
- Since there are a number of agencies involved with water supply, the crucial relationship between water infrastructure and urban/economic development.
- The highly capital intensive nature of the sector and the over-whelming presence of sunk costs, which increase private-sector risks.
- The multipurpose and hydraulically interconnected nature of the water resource itself.

For MCJ, the privatization of assets is not recommended under the present circumstances. Instead, it is proposed that Private sector should be involved in building the infrastructure and capacity building of the MC. It is also recommended that an incentive based approach should be used for involving the private sector since it would improve the services provided by the private sector party. Feasibility of management contracts/BOOT arrangements for operation and management of water treatment plants and distribution networks may however be explored.

On the basis of this discussion, certain recommendations for private sector involvement are proposed below. It is important to realize that the choice of public-private arrangements would constantly change over time. Thus, no specific long term strategies are proposed. It is however recommended that a detailed study should be undertaken to study and identify the role of private sector in water supply in Jabalpur before taking a decision on the type of partnership that would be suitable in the long run. Internationally existing options which may be considered for evolving the Public Private relation in Jabalpur are given in Table 7.7.

#### *7.4.9.1 Building new infrastructure*

Private Sector involvement for building of new infrastructure ranging from construction of pump houses, water treatment plants, expanding the IT infrastructure or GIS mapping etc., should be preferred as the MCJ is not equipped to carry out such a task and building capacity for each task is financially not feasible.

#### *7.4.9.2 Management of Services*

Involvement of Private Sector for management of services is recommended only in the short and medium run. For this, involvement of the private sector is envisaged in billing, collection and leak detection and repair.

#### *7.4.9.3 Maintenance of existing infrastructure*

It is proposed that contracts could be given out to Private parties for maintenance of pump houses and water treatment plants. Separate contracts could be given out for repairing and replacing of pipelines wherever required, but this should be considered only in the short and medium term.

**Table 7.6** Indian experience in Privatisation of Water Supply & Sanitation

| | |
|---|---|
| Tirupur Water Supply and Sewerage Project | • Implemented through a SPV New Tirupur Area Development Corporation (NTADC) promoted by:<br>– Infrastructure Leasing & Financing Services (IL&FS)<br>– Tirupur Exporters' Association (TEA)<br>– Tamil Nadu Corporation for Industrial Infrastructure Development (TACID)<br>• Estimated Project cost – Rs. 900 Crores at 1998 prices (Rs. 1000 crore at present)<br>– O&M contract to consortium of Mahindra & Mahindra<br>– United Utilities International North West Water +Bechtel<br>– Attained financial closure with 10% stake by LIC & GIC. |
| Pune Water Supply and Sewerage Project | • Developed by Pune Municipal Corporation at a estimated project cost of Rs. 750 crores ($ 187.5 M) later revised to Rs. 392 Crores with HUDCO assistance<br>– Private Sector Participation envisaged in Construction, Operation and Maintenance, Tariff collection<br>– Financial Participation expected from IL&FS, ICICI, HDFC, IDFC and Bank of Maharashtra, in addition to HUDCO<br>– Request for proposal sought<br>– Tie-ups: Anglian Water + Trafalgar House & Shirkes Binnie Black + Veatch & Thames Water + L&T Krugger + Generale Des eaux & Shanska Int. Preussag + Tata Projects Hyundai + Sundram Chemicals+ Hanjin + Krupp and Zoom Development Group<br>– Political Risk – work re-tendered at RfP level |
| Bangalore Water Supply Project | • BOOT arrangement for sourcing 500 mld water.<br>– Establishment of two Tertiary Water Treatment Plants (of total 60 mld capacity) with HUDCO assistance<br>– Private Sector (Industries) to undertake laying of feeder mains<br>– envisages provision of 500 mld of water to the city on a BOT basis with estimated project cost is Rs. 800 Crores (US$ 173 M). |
| Chennai Metro Water | • Out of 119 Sewerage Pumping Stations, Operation & Maintenance of 70 by private sector<br>• Sourcing of water in 7 wells through private sector<br>• Construction of 300 mld Water Treatment Plant by – M/s Hindustan Dorr Oliver Ltd. and O&M by M/s Richardson Cruddas<br>• New Chembarampakkam WTP of 530 mld capacity (over and above the existing 600 mld capacity)<br>– Bid documents for BOT by TCS<br>– HUDCO funding availed |
| Karnataka Urban Water Supply and Drainage Board (KUWS&DB) | • Management Contract in Distribution and O&M<br>• Towns selected for the initiative are<br>– Mysore<br>– Mangalore<br>– Hubli – Dharwad<br>– Gulbarga |
| Others | • Private Sector Participation on the anvil in water supply & sanitation<br>– Nagpur<br>– Dewas<br>– Kolhapur<br>– Cochin<br>– Vishakhapatnam<br>– Dharwad<br>– Goa<br>– Alandur |

**Source**: Presentation on Innovative Infrastructure Financing by V Suresh, Director General, Good Governance India and Former Chairman and Managing Director, HUDCO

**Table 7.7** International examples of options for private sector participation and allocation of responsibilities

| Option | Asset Ownership | O & M | Capital Investment | Commercial Risk | Duration | Examples |
|---|---|---|---|---|---|---|
| Service Contract | Public | Public and Private | Public | Public | 1-2 Years | Chile (Santiago)<br>India (Chennai) |
| Management Contract | Public | Private | Public | Public | 3-5 Years | Gaza<br>Trinidad and Tobago |
| Lease | Public | Private | Public | Shared | 8-15 Years | Guinea (17 cities)<br>Poland (Gdansk) |
| Build-Operate-Transfer | Private (bulk services) | Private | Private | Private | 20-30 Years | Malaysia (Johor)<br>Australia (Sydney) |
| Concession | Public | Private | Private | Private | 25-30 Years | Argentina (Buenos Aires) Cote d'Ivoire<br>Philippines (Manila) |
| Divestiture | Private | Private | Private | Private | Indefinite | England and Wales |

# Annexures

# Annexure 3.1

## Aqualibre Water Balance Model

### System Data

*Water Undertaking Details*

| | | |
|---|---|---|
| Water Undertaking | Municipal Corporation of Jabalpur | |
| Address | | |
| City | State | Zip |
| Tel | Fax | e-mail |
| Contact Person | | |

| System Pressure | | Error % |
|---|---|---|
| Average System Pressuremeters | 3.00 | 15 |
| Percentage Time Pressurised | 8.33 | 15 |

| Customer Meters | | Error % |
|---|---|---|
| Total Customer Meters | | |

| Mains | Kilometers | Error % |
|---|---|---|
| Total Trunk Mains | 63.0 | 20.0 |
| Total Distribution Mains | 480.0 | 30.0 |
| Total Mains | 543 | 26.6 |

| Connections and Properties | | Error % |
|---|---|---|
| Total Number of Units | 47,153 | 10.0 |
| Total Connections | 47,153 | 10.0 |
| Total Properties | 47,153 | 10.0 |

## Aqualibre Water Balance Model

| | |
|---|---|
| Name of Water Undertaking | Municipal Corporation of Jabalpur |
| Supply Area: | |
| Period of Record: | December 2004 to November 2005 (365 days) |
| Water Balance Units: | cubic meters |

### Primary Water Balance

| | | |
|---|---|---|
| System Input: Own Sources | 55,020,730.72 | 4.9 |
| Ranjhi Treatment Plant | 13,030,500 | 5.0 |
| Bhonga Dwar | 8,121,250 | 10.0 |
| Lalpur Treatment Plant | 26,937,000 | 5.0 |
| Tubewells | 6,931,980.72 | 30.0 |
| System Input: Imported Sources | | |
| Total System Input | 55,020,730.72 | 4.9 |
| Billed metered Consumption: Domestic Consumers | | |
| Billed metered Consumption: Non-Domestic Consumers | 4,443,875 | 5.0 |
| Bulk consumers | 4,443,875 | 5.0 |
| Total Billed metered | 4,443,875 | 5.0 |
| Billed Unmetered Consumption: Domestic Consumers | 29,687,044 | 4.9 |
| Supply from all OHTs | 27,617,142.82 | 5.0 |
| Supply from Tubewells to OHT | 109,500 | 10.0 |
| Direct Supply | 1,960,401.22 | 25.0 |
| Billed Unmetered Consumption: Non-Domestic Consumers | 576,700 | 15.0 |
| Bulk Unmetered | 576,700 | 15.0 |
| Total Billed Unmetered Consumption | 30,263,744 | 4.8 |

| | | |
|---|---|---|
| Unbilled metered Consumption | | |
| | | |
| Unbilled Unmetered Consumption: Domestic Consumers | 1,695,421.41 | 20.2 |
| Public Standpost | 1,018,861 | 30.0 |
| Tankers | 57,670 | 25.0 |
| Religious Connections | 618,890.41 | 25.0 |
| | | |
| Customer metering Inaccuracies and Data Handling Errors | | |
| Total Metering Error | | |
| Data Handling Error | | |
| | | |
| Unauthorised Use | 17,337,500 | 30.0 |
| Illegal Connections on distribution lines and rising mains | 17,337,500 | 30.0 |
| | | |
| Losses from Storage Facilities | 17,260.72 | 25.0 |
| Storage Facility Losses | 17,260.72 | |
| Losses by Volume | | |

## Aqualibre Water Balance Model

### Primary Water Balance Summary

| | Cubic meters | Error % |
|---|---|---|
| **Billed Authorised Consumption** | **34,707,619** | **4.2** |
| Billed Metered Consumption | 4,443,875 | 5.0 |
| Billed Unmetered Consumption | 30,263,744 | 4.8 |
| **Unbilled Authorised Consumption** | **1,695,421.41** | **20.2** |
| Unbilled Metered Consumption | | |
| Unbilled Unmetered Consumption | 1,695,421.41 | 20.2 |
| **Apparent Losses** | **17,337,500** | **30.0** |
| Unauthorised Use | 17,337,500 | 30.0 |
| Consumption Meter Error | | |
| Total System Input | 55,020,730.72 | 4.9 |
| Water Losses | 18,617,690.27 | 16.6 |
| Apparent Losses | 17,337,500 | 30.0 |
| Real Losses | 1,280,190.27 | 472.6 |
| Bulk Storage Leakage and Overflow | 17,260.72 | 25.0 |
| Revenue Water | 34,707,619 | 4.2 |
| Non-Revenue Water | 20,313,111.68 | 15.3 |

## Aqualibre Water Balance Model

### Water Losses Balance

| | Cubic meters | Error % |
|---|---|---|
| Total Real Losses | 1,280,190.27 | 472.6 |
| Background Leakage | | |
| Properties | | |
| Connections | | |
| Mains | | |
| **Total** | | |
| Reported Bursts | | |
| Mains | 3,360.32 | 30.2 |
| Connections | | |
| **Total** | **3,360.32** | **30.2** |
| Unreported Bursts | | |
| Mains | 6,018.98 | 21.2 |
| Connections | | |
| **Total** | **6,018.98** | **21.2** |
| Losses from Storage Facilities | | |
| Bulk Storage Losses | 17,260.72 | |
| Losses by Volume | | |
| **Total** | **17,260.72** | **25.0** |
| Excess or Hidden Losses | 1,253,550.25 | 482.6 |

## Background Leakage

### System Pressure and Supply Factor

| | | |
|---|---|---|
| System Pressure | 3.0 | Error % 15 |
| Intermittent Supply Factor | 8.33 | Error % 15 |
| Background Pressure Exponent (N1) | 1.50 | |
| Pressure Correction Factor | 0.014697 | |

### Property Leakage

| | | |
|---|---|---|
| Number of Properties | 47,153 | |
| Leakage Rate l/property/hr | | |
| Poperty Leakage m^3 | | Error % 10.0 |

### Connection Leakage

| | Mains to Property Line | Property Line to Meter |
|---|---|---|
| Number of Connections | 47,153 | 47,153 |
| Leakage Rate l/connections/hr | | |
| Connections Leakage m^3 | | |
| Error Percentage | 10.0 | 10.0 |

### Main Leakage

| | Length kilometers | l/km/hr | m^3 | Error % |
|---|---|---|---|---|
| Total Trunk Mains | 63.0 | | | 20.0 |
| Total Distribution Mains | 480.0 | | | 30.0 |
| Total | 543 | | | |

### Total Leakage

| | |
|---|---|
| Total m^3 | Error % |

# Aqualibre Water Balance Model

## Burst Leakage

Pressures and Supply Factors

| | meters | Error % | Supply Factor | Error % | N1 Exponent | Correction Factor |
|---|---|---|---|---|---|---|
| System Pressure | 3.0 | 15 | 8.33 | 15 | 0.50 | 0.24495 |
| Trunk Mains | 70.00 | 20 | 90 | 20 | 0.50 | 1.1832 |

Trunk Mains Bursts

| | Number | m^3/hr | Duration (days) | m^3 | Error % |
|---|---|---|---|---|---|
| Reported | 1 | 11.83 | 7.4 | 1,890.91 | 50.0 |
| Unreported | 1 | 5.92 | 8.0 | 1,022.98 | 25.0 |
| Total | 2 | | | 2,913.89 | 36.3 |

Distribution Mains Bursts

| | Number | m^3/hr | Duration (days) | m^3 | Error % |
|---|---|---|---|---|---|
| Reported | 300 | 0.49 | 5.0 | 1,469.41 | 25.0 |
| Unreported | 300 | 0.49 | 17.0 | 4,996.00 | 25.0 |
| Total | 600 | | | 6,465.41 | 20.1 |

Connection Bursts: Mains to Property Line

| | Number | m^3/hr | Duration (days) | m^3 | Error % |
|---|---|---|---|---|---|
| Reported | | 0.39 | 14.1 | | |
| Unreported | | 0.39 | 185.6 | | |
| Total | | | | | |

Connection Bursts: Property Line to Meter

| | Number | m^3/hr | Duration (days) | m^3 | Error % |
|---|---|---|---|---|---|
| Reported | | 0.39 | 14.1 | | |
| Unreported | | 0.39 | 185.6 | | |
| Total | | | | | |

Total Bursts and Losses

| | Number | | m^3/hr | Error % |
|---|---|---|---|---|
| Total Bursts | 602 | Total Burst Losses | 9,379.30 | 17.3 |

## Aqualibre Water Balance Model

### Performance Indicators

| **Base Data Used in Calculations** | Value | Error % | Lower Estimate | Upper Estimate |
|---|---|---|---|---|
| Averager pipe length from street edge to meter | 1.50 | 20 | 1.2 | 1.8 |
| Length of trunk mains | 63.0 | 20.0 | 50 | 76 |
| Length of distribution mains | 480 | 30.0 | 336 | 624 |
| No. of Service Connections | 47,153 | 10.0 | 42,438 | 51,868 |
| Connection Density (distribution mains) | 98.24 | 31.6 | 67.17 | 129.30 |
| Average System Pressure | 3.0 | 20 | 56.0 | 84.0 |
| Average Trunk Pressure | 70.00 | 20 | 2.6 | 3.5 |
| Percentage time pressurised - System | 8.33 | 15 | 7.1 | 9.6 |
| Percentage time pressurised - Trunk Mains | 90 | 20 | 72.0 | 100.0 |
| Number of Accounts | 47,153 | 10.0 | 42,456 | 51,850 |

| **Unavoidable Annual Real Losses** | m^3/day | Error % |
|---|---|---|
| On Trunk Mains | 71 | 34.6 |
| On Distribution Mains | 2 | 30.5 |
| On service connections to street boundary | 9 | 18.4 |
| On service connections to street edge to meter | 0 | 27.2 |
| Total unavoidable real losses | 82 | 23.0 |

| **Cost of Running the System** | Monetary unit/m^3 | Monetary unit |
|---|---|---|
| Real Loss Cost: | Apparent loss cost: | System Cost: |

| **Performance Indicators** | Best Estimate | Lower Estimate | Upper Estimate |
|---|---|---|---|
| Non Revenue Water Basic (IWA Level 1, Fi37)<br>Percentage System Input by Volume | 36.9 | 30.5 | 43.3 |
| Non Revenue Water Basic (IWA Level 1, Fi38)<br>Percentage System Input by Value | | | |
| Real Losses Basic (IWA Level 1, Op24) | | | |
| l/connection/day when pressurised | 893.0 | -3,320.2 | 5,116.1 |
| l/km mains /day | 87,719.4 | -327,885.1 | 503,323.8 |
| Real Losses Intermediate | | | |
| l/connection/day/ m pressure when pressurised | 297.7 | -1,113.3 | 1,708.6 |
| l/km mains /day/m pressure | 29,239.8 | -109,364.4 | 167,844.0 |
| Real Losses Detailed (IWA Level 3, Op25)<br>Infrastructure Leakage Index | 42.77 | 0.00 | 245.16 |

# Annexure 5.1a

**Activity schedule for Metering of Bulk flows (as per proposed Implementation plan for short term)**

(Bulk management meters and Bulk revenue meters)

| | | Months# (by the end of) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S. No.** | | **#1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** |
| **1** | Identifying exact locations for installation of bulk meters, V-notches and level gauges on the entire supply scheme* | | | | | | | | | | | | | | | | |
| **2** | Tendering process for procurement (and installation) of bulk meters, V notches and level gauges at select locations** | | | | | | | | | | | | | | | | |
| **3** | Preparing a comprehensive list of bulk consumers and industrial consumers | | | | | | | | | | | | | | | | |
| **4** | Initiating the process to install bulk revenue meters on inlets of identified bulk consumers and industrial consumers | | | | | | | | | | | | | | | | |
| **5** | Refining the MIS for recording and analysis of flow | | | | | | | | | | | | | | | | |
| **6** | Installation of bulk management meters at identified locations*** | | | | | | | | | | | | | | | | |
| **7** | Preparing (and making available) guidelines for procurement and installation of bulk revenue meters to the bulk and industrial consumers | | | | | | | | | | | | | | | | |
| **8** | Monitoring and documentation of water flows | | | | | | | | | | | | | | | | |
| **9** | Capacity building of staff on flow metering, calibration and upkeep or records | | | | | | | | | | | | | | | | |
| **10** | Installation of V notches and level gauges | | | | | | | | | | | | | | | | |
| **11** | Installation of bulk revenue meters at inlet of bulk consumers and industrial consumers | | | | | | | | | | | | | | | | |
| **12** | Installation of bulk management meters at remaining locations | | | | | | | | | | | | | | | | |
| **13** | Inspection of bulk revenue meters and Calibration of all installed meters | | | | | | | | | | | | | | | | |

# wef a decided zero date

* It is recommended that all locations for first and second phase be identified during this activity and preferably marked on a GIS map

** with a condition to extend it on the same terms and conditions

*** This could be split in two sub phases
(Phase I to install 30-50% of the bulk meters and study their performance, Phase II to install bulk meters at the remaining locations)

*** Bulk meter supplier could be asked to install and calibrate/maintain the flow meter

## Annexure 5.1b

**Activity schedule for Domestic metering (as per proposed Implementation plan for short term)**

| S.No. | Activity | Months# (by the end of) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | #1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | Identifying pilot areas for installation of domestic meters* | | | | | | | | | | | | |
| 2 | Initiating dialogue with RWAs of these pilot areas and creating consumer awareness | | | | | | | | | | | | |
| 3 | Identifying properties in each pilot area for installation of domestic meters | | | | | | | | | | | | |
| 4 | Initiating dialogue with different manufacturers/suppliers of domestic consumer meters** for pilot assessment of metering and different meters | | | | | | | | | | | | |
| 5 | Updating the list of domestic consumers and Refining the MIS for recording and analysis of flow | | | | | | | | | | | | |
| 6 | Preparing plan for installation of meters and protocol on performance monitoring schedule for assessment of meters | | | | | | | | | | | | |
| 7 | Installation of domestic consumer meters at the identified locations | | | | | | | | | | | | |
| 8 | Assessment of flows, water auditing and performance measurement of the installed meters | | | | | | | | | | | | |
| 9 | Discussion of results with experts and RWAs | | | | | | | | | | | | |
| 10 | Finalizing guidelines for domestic consumers on the procurement, installation and maintenance/calibration of meters (based on experience of Municipal Corporation) | | | | | | | | | | | | |
| 11 | Deciding terms for charging the fixed cost of domestic meters and the tariff plan for consumers having domestic meters | | | | | | | | | | | | |
| 12 | Modifying existing MIS for bill generation (to be based on meter reading) | | | | | | | | | | | | |

# wef a decided zero date
* should ideally begin once bulk meters have been installed
** From the list of manufacturers approved by different agencies like FCRI, CWRPS and IDEMI

## Annexure 5.1c

**Activity schedule for developing GIS database (as per proposed Implementation plan for short term)**

| | | Months# (end of) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S. No.** | **Strategies to be Implemented** | **#1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** |
| **1** | Collecting all existing maps | | | | | | | | | | | | | | | | |
| **2** | Creation of all existing maps on a GIS database | | | | | | | | | | | | | | | | |
| **3** | Field survey of Transmission networks using GPS and updation of all details* | | | | | | | | | | | | | | | | |
| **4** | Field Survey of Distribution networks of pilot study area by Engineers using GPS and updation of all details | | | | | | | | | | | | | | | | |
| **5** | Creation of GIS department | | | | | | | | | | | | | | | | |
| **6** | Capacity building of the staff and changes in MIS system | | | | | | | | | | | | | | | | |
| **7** | Integrating details like revenue generation at ward level and other administrative information in the developed database as an attribute information $ | | | | | | | | | | | | | | | | |
| **8** | Integration with consumer MIS $ | | | | | | | | | | | | | | | | |

\# wef a decided zero date
* Including locations of proposed bulk metering infrastructure
$ This activity shall extend to the medium term

# Annexure 5.1d

**Activity schedule for Active and Passive leakage control (as per proposed Implementation plan for short term)**

| | | Months# (end of) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S. No.** | **Strategies to be Implemented** | **#1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** |
| 1 | Identifying team for leakage detection | | | | | | | | | | | | | | | | |
| 2 | Capacity building of the staff in leak detection | | | | | | | | | | | | | | | | |
| 3 | Identifying different pilot distribution areas (representative of the pipe infrastructure) | | | | | | | | | | | | | | | | |
| 4 | Undertaking leakage assessment in transmission network and analysis | | | | | | | | | | | | | | | | |
| 5 | Repairing leakages in transmission mains | | | | | | | | | | | | | | | | |
| 6 | Identifying and repairing leakages in representative Pilot Study areas | | | | | | | | | | | | | | | | |
| 7 | IIdentifying and repairing leakages in pump houses | | | | | | | | | | | | | | | | |
| 8 | Revamping the existing system for passive leakage control | | | | | | | | | | | | | | | | |
| 9 | Establishment of Private call centre for reporting leak complaints | | | | | | | | | | | | | | | | |
| 10 | Documentation of all types of leakage and its location in GIS map | | | | | | | | | | | | | | | | |
| 11 | Identifying more areas (in different wards) for future leakage assessment exercise* | | | | | | | | | | | | | | | | |

\# wef a decided zero date

* Based on observations and experience from the exercise undertaken in pilot areas

## Annexure 5.1e

**Activity schedule for Alternative supply means (as per proposed Implementation plan for short term)**

| S.No. | Strategies to be Implemented | Months# (by the end of) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | #1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | Modernising existing system for tanker filling (installing meters and devices so as to avoid wastages in filling) | | | | | | | | | | | | |
| 2 | Improving the condition of all tankers to avoid spillages and deterioration in quality | | | | | | | | | | | | |
| 3 | Consumer awareness of small pipe network system | | | | | | | | | | | | |
| 4 | Introducing small pipe networks or water kiosks for Tanker supplied areas | | | | | | | | | | | | |
| 5 | Phasing out tankers and other supply system and installation of piped water supplies from main supplies keeping tankers supplies only during emergency | | | | | | | | | | | | |

# wef a decided zero date

## Annexure 5.2a

# Water Meters

Flow measurement is of paramount importance to water utilities from a management perspective and revenue perspective. From a management perspective flow measurement is the most important tool for planning and optimisation of any water network while on the revenue side metering is important to ensure the consumers pay according to the consumption. It also helps to establish the total water losses in a network.

### Types of water meters

A water utility would essentially be using two meters for two purposes:

- Management of the system (Bulk management meters): Bulk management meters are used to measure flow at critical points in the network to establish a water balance. Bulk management meters generally used are either mechanical types or electromagnetic types. Mechanical meters are used for pipe size up to 500 mm, as above that the accuracy of bulk management meters is not very good. Electromagnetic meters are normally used for larger pipe diameters since these are financially viable than mechanical meters above a size of 300 mm diameter. In addition, the utility may also use potable ultrasonic flow meters for taking instantaneous logging and also for the purpose of carrying out audits.
- Revenue meters: Revenue meters most commonly used are the turbine meters. They are available in sizes ranging from 15 mm to 800mm. However accuracy is less in larger meters. They may be used for revenue purposed for both domestic and bulk connections. According to the IS codes on the basis of consumer category the water meters may be divided into:
  a. **Domestic Meter:** Water meters having sizes from 15 mm to 50 mm as per the BIS 779: 1994 are considered to be the domestic meter. These meters could be made of brass or bronze and are available in Class 'A' and 'B' in IS: 779:1994. However, domestic meters are also supplied in Class C and Class D in many places across the world.
  b. **Bulk meter:** Water meters having sizes 50 mm and above (BIS 2373: 1981) are considered to be the bulk meters. These meters have flanged connections and are usually made of steel or cast iron. These meters are not available in classes in IS.

Figure 1 gives the various types of meters used in water utilities.

The operational details of various types of meters are described in sections below:

On the basis of operating principle the water meters can be classified as inferential or semi positive.

a. ***Inferential meters:*** Also known as velocity meters or turbine meters. These are the meters, which measures the velocity of flow from which the discharge is measured. These meters could further be divided as single jet and multi jet and Woltman or helical type.
  - *Single jet:* Single jet meters are available from 15mm to 300mm as per IS 779:1994 and 15mm to 100mm as per ISO 4064. The single jet meters are cheapest and less complicated. The pressure loss is also minimum. Irrespective of the advantages the single jet meters have some disadvantages too. They are sensitive to flow disturbances and require specialized calibration, as external regulator is not available.

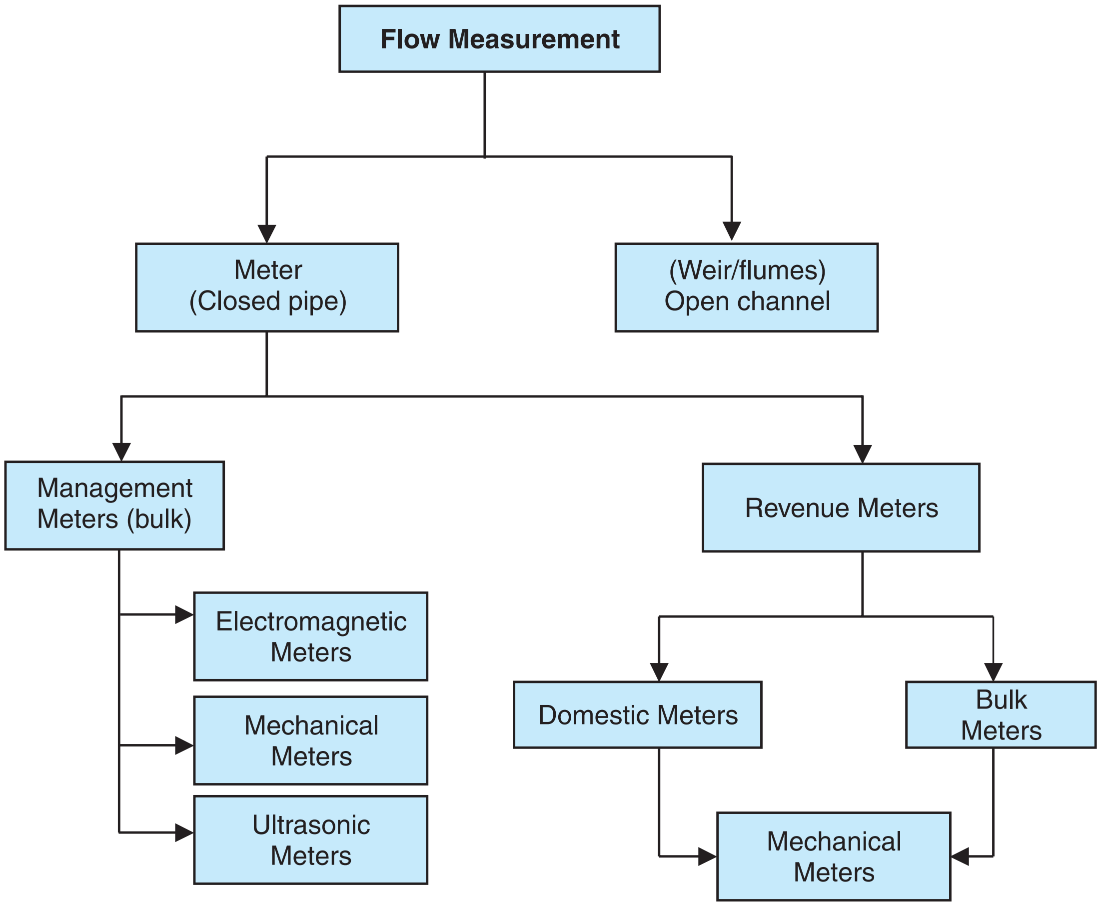



**Figure 1** Types of flow meters

- *Multi jet:* The multi jet meters are available from 15mm to 300mm as per ISO 4064. Multi jet meters have the advantage that they are less sensitive to the flow disturbances and can sustain hostile flow conditions. They are provided with external regulator, which facilitates easy calibration, but they are more costly than the single jet meters and the pressure loss is also more than the single jet meters.
- *Woltman or helical type:* These meters are available from 50 mm to 500 mm as per BIS 779; 1994 and 50 mm to 800 mm as per ISO 4064. These meters are suitable for higher flows and are provided with external as well as internal regulators. They are robust meters and also the pressure loss is minimum.

**b. *Semi-positive meters:*** Semi-positive meters are the meters, which volumetrically records practically close to zero flow of the water that has passed through, with a small unavoidable leakage. It is recommended to install such meters at places where the water supply is free from solid impurities, as the failure of the rotating part causes the failure of water flow from the meter thereby stopping the water supply. Usually these meters are not suitable for the Indian conditions.

### Types of metering systems for measuring bulk flows

There are two types of water transporting systems: Open channel and close channel/pipes. Open channel or flumes are designed to convey water from sources like dams, rivers to farms, treatment plants, etc. Open channels are constructed where the water is to be supplied though gravity. Closed conduit or pipes are designed to convey water under pressure. Pipes are used for transmitting and distributing water under pressure from the treatment plants to the city. Table 1 shows the different types of metering systems for measuring bulk flows:

**Table 1** Different types of metering systems

| | Type | Subtypes |
|---|---|---|
| Closed channels | Differential pressure meters | Orifice/venturi tubes/variable area meters etc. |
| | Positive displacement meters | Pistons/ oval gears/nutating disk etc. |
| | Velocity meters | Electromagnetic/ultrasonic etc. |
| Open channels | Weirs and flumes | V-notch etc. |

Numerous types of bulk flow meters are available for closed piping systems. In general, the equipment can be classified as differential pressure, positive displacement and velocity meters. Differential pressure devices (also known as head meters) include orifices, venturi tubes, flow tubes, flow nozzles, pitot tubes, elbow-tap meters, target meters and variable area meters.

Positive displacement meters include pistons, oval-gear, nutating-disk, and rotary-vane types. Velocity meters consist of turbine, electromagnetic, and sonic designs.

The measurement of liquid flows in open channels generally involves weirs and flumes.

## 1. Velocity meters

These instruments operate linearly with respect to the volume flow rate. Most velocity type meter housings are equipped with flanges or fittings to permit them to be connected directly into pipelines.

### a. Electromagnetic Flow Meters

Magnetic flow meters have been commercially available since the mid 1950's, measuring the flow of water and a wide range of other electrically conductive liquids, including corrosives, slurries and sludge in closed pipe systems.

Operating Principle: Faraday's Law of Electromagnetic Induction is the underlying principle of operation for magnetic flow meters. This law states that the magnitude of the voltage induced in a conductive medium moving through a magnetic field and at right angles to the field is directly proportional to the product of the strength of the magnetic flux density (B), the velocity of the medium (V), and the path length (L) between the probes.

E = constant x B x L x V
Where; E= Voltage generated in a conductor
V= Velocity of the moving conductor
B= Strength of the magnetic field
L= length of the conductor path (distance between probes)

### b. Ultrasonic Flow Meters

The Ultrasonic technologies in general use for closed piping applications are Doppler and transit time.

- **Doppler meters**

With Doppler meters, an ultrasonic pulse is beamed into the pipe and reflected by inclusions, such as air or dirt. The Doppler meter is frequently used as a "clamp on" device, which can be fitted to existing pipelines. The non-invasive flow sensing capability of these meters provided by their "clamp-on" transducer offers a variety of advantages, including:

- Quick, easy setup
- Permanent or temporary flow measurement
- No need to break into piping
- No production downtime
- No wetted parts to plug up flow passage
- Complete chemical compatibility
- Measures a wide range of flowing media, from clean liquids to slurries
- No pressure drop

Operating Principle: The Ultrasonic Doppler Shift Flow Meter employs a non-invasive piezoelectric transducer, hand-held or clamped on the outside surface of a full pipe, to transmit a continuous single frequency ultrasound through the pipe wall, into the flowing liquid. This signal is reflected from suspended particles, bubbles or eddies and relayed to second receiver transducer (or a second receiving piezoelectric crystal within the same transducer). The meter's microprocessor compares frequency shift (Doppler Effect) between the transmitted and returned signal. The degree of the Doppler Shift is proportional to the forward velocity of the flowing liquid.

Conventional ultrasonic Doppler technology can effectively measure flowing liquids containing suspended particles or entrained gases (air) larger than 30 microns size, in concentrations greater than 25 PPM. Some enhanced Doppler designs can measure cleaner liquids (with fewer and/or smaller discontinuities) by sensing the turbulent swirls and eddies in the flow stream induced by non-symmetrical pipe configuration (i.e. elbows).

The non-invasive transducers can effectively transmit signals through PVC, steel, iron and glass pipe walls. However, lined pipes and concrete pipes block the ultrasonic signal.

## Transit Time

Transit Time Flow Meters (as shown in Figure 1) feature the most advanced non-invasive flow measurement technology available. These meters provide a low cost system with unsurpassed accuracy and versatility.

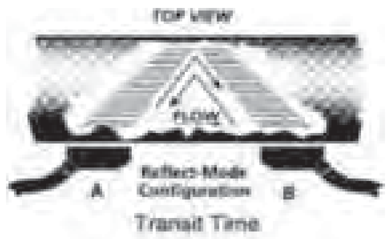


**Figure 1** Transit time flow meter

Operating Principle: The Transit Time Flow Meter utilizes two transducers, which function as both ultrasonic transmitters and receivers. The flow meter operates by alternately transmitting and receiving a frequency modulated burst of sound energy between the two transducers. The burst is first transmitted in the direction of fluid flow and then against fluid flow. Since sound energy in a moving liquid is carried faster when it travels in the direction of fluid flow (downstream) than it does when it travels against fluid flow (upstream), a differential in the times of flight will occur. The sound's time of flight is accurately measured in both directions and the difference in time of flight calculated. The liquid velocity (V) inside the pipe can be related to the difference in time of flight (dt) through the following equation: $V = K*D*dt$, where K is a constant and D is the distance between the transducers.

### c. Mechanical flow meters

Mechanical flow meters measure flow using an arrangement of moving parts, either by passing isolated, known volumes of a fluid through a series of gears or chambers (positive displacement, or PD) or by means of a spinning turbine or rotor.

**i. Turbine meters**

Invented by Reinhard Woltman in the 18th century, the turbine flow meter is an accurate and reliable flow meter for both liquids and gases. It consists of a multi-bladed rotor mounted at right angles to the flow and suspended in the fluid stream on a free-running bearing. The diameter of the rotor is very slightly less than the inside diameter of the metering chamber, and its speed of rotation is proportional to the volumetric flow rate. Turbine rotation can be detected by solid-state devices (reluctance, inductance, capacitive and Hall-effect pick-ups) or by mechanical sensors (gear or magnetic drives).

**ii. Paddle Wheel Flow Meters**

Using paddle wheel type probes is one of the least expensive ways of measuring liquid flow in larger pipes (up to 12 in., or 305mm) as shown in Figure 2. The rotation of the paddle wheel can be detected magnetically or optically, and the different manufacturers offer these probes in plastic and metallic materials.

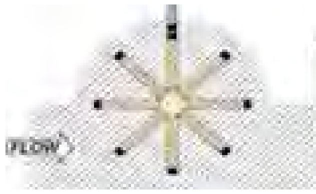


**Figure 2** Paddle wheel flow meter

Operating Principle: In paddle wheel flow meters, the paddle wheel (rotor with rotary vaned blades) is perpendicular to the flow path, not parallel as in the traditional turbine-type flow meter. The rotor's axis is positioned to limit contact between the paddles and the flowing media to less than 50% of the rotational cycle. This imbalance causes the paddle to rotate at a speed proportional to the velocity of the flowing media.

## 2. Positive displacement liquid meters

Positive displacement meters split the flow of liquids into separate known volumes based on the physical dimensions of the meter, and count them or totalize them. They are mechanical meters in that one or the other moving parts, located in the flow stream, physically separate the fluid into increments. Energy to drive these parts is extracted from the flow stream and shows up as pressure loss between the inlet and outlet of the meter. The general accuracy of these meters is dependent upon minimizing clearances between the moving and the stationary parts and maximizing length of this leakage path. For this reason meter accuracy tends to increase as size increases.

The positive displacement meters include piston, oval-gear, nutating-disk, and rotary vane types.

**a. Oval Gear Flow Meters**

A special variety of the rotating lobe flow meter is the oval-geared metering elements as shown in Figure 3.

Operating Principle**:** Incoming liquid (upstream pressure) exerts a pressure differential against the (upstream end) lower face of oval gear A, causing the two interlocked oval gears to rotate to position 2. In this second position, the flowing liquid enters the cavity between oval gear B and the flow meter body wall, while an equal volume of liquid simultaneously passes out of the cavity between oval gear A and the flow meter body wall.

Meanwhile, upstream pressure continues to force the two oval gears to rotate to position 3. At this position, a predetermined quantity of liquid has again filled the cavity between oval gear B and the flow meter body.

This pattern is continuously repeated moving four times the liquid capacity of each cavity with each revolution of the rotating gears. Therefore, the flow rate is proportional to the rotational speed of the

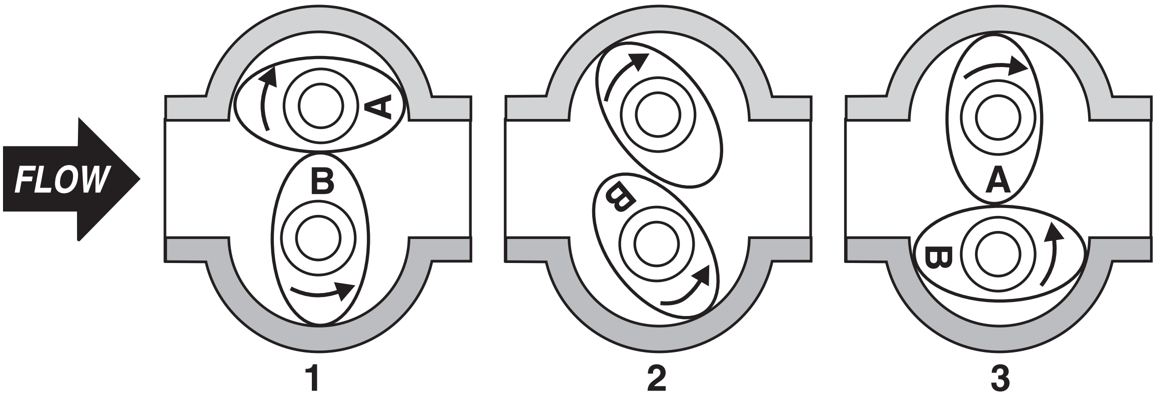



**Figure 3** Oval gear flow meter

gears. Magnets, imbedded in each end of the rotating oval gears, are used to open and close a reed switch output signal, activate a microprocessor or Hall Effect Pickup to transmit the internal motion (rotational count) to a usable output signal.

### b. Nutating-disk meters

This meter also known as disk meter is used extensively for residential water service. The moving assembly, which separates the fluid into increments, consists of an assembly of a radially slotted disk with an integral ball bearing and an axial pin. This part fits into and divides the metering chamber into four volumes, two above the disk on the inlet side and two below the disk on the outlet side. As the liquid attempts to flow through the meter, the pressure drop from inlet to outlet causes the disk to wobble, or nutate, and for each cycle to display a volume equal to the volume of the metering chamber minus the volume of the disk assembly. The end of the axial pin, which moves in a circular motion, drives a cam that is connected to a gear train and the totalizing register. This flow meter has an accuracy of about ±1 to 2%. It is built for small pipe sizes.

### c. Rotary Vane Flow Meters

These meters use the well-established, low maintenance rotary vane impeller-type measuring mechanism. Designed with minimum moving parts, these meters provide reliable, trouble free operation (shown in Figure 4).

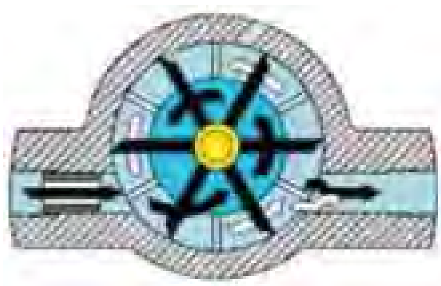


**Figure 4** Rotary vane flow meter

Operating Principle: Rotary vane meters are manufactured in several designs, but the principle of operation is identical for all of these meters. Liquid enters the cylindrical measuring chamber and is forced to separate into two equal streams, travelling in a 360° loop. The streams are further channeled, by the special configuration of the measuring chamber, into a series of vortices which cause the rotary vaned impeller to rotate in direct proportion to the flow rate. These dual flow streams are recombined into a single stream at the meter outlet. The rotary impeller is connected to the meter register by a magnetic d3rive assembly. Each impeller rotation is mechanically tabulated and displayed by the meter register.

## 3. Differential Pressure Flow Metering Technology

Differential pressure type flow meters have been the most widely applied technology of all the flow measurement technologies available. In addition to the orifice plate flow meter, the most commonly used, the differential pressure technology also includes the widest variety of subcategories, or types.

The most commonly used types include:

- Venturi
- Nozzle
- Pivot-static Tube
- Elbow
- Wedge

Other newer designs include:

- V-cone
- Spring-loaded Variable Aperture
- Laminar Flow Element
- Dall Tube
- Elliot-Nathan Flow Tube
- Dall Orifice
- Epiflo

Operating Principle: In general, differential pressure flow meters feature a restriction in the cross sectional area of the flow path that causes a differential pressure to be developed between two points in the flow path. The difference in pressure between the upstream and downstream points of measurement is caused by a change in fluid flow velocity.

Therefore, the basic operating principle of differential pressure flow meters is based on the premise that the pressure drop across the meter is proportional to the square of the flow rate. The flow rate is obtained by measuring the pressure differential and extracting the square root.

Differential pressure flow meters, like most flow meters, have a primary and secondary element. The primary element causes a change in kinetic energy, which creates the differential pressure in the pipe. The secondary element measures the differential pressure and provides the signal or read out that is converted to the actual flow value.

a. **Orifices:** Orifices are the most popular liquid flow meters in use today. An orifice is simply a flat piece of metal with a specific sized hole bored in it. Most orifice are concentric type, but eccentric, conical (quadrant) and segmental designs are also available.

   In practice, the orifice plate is installed in the pipe between the two flanges. Acting as the primary device, the orifice constricts the flow of liquid to produce a differential pressure across the plate. Pressure taps on either side of the plate are used to detect the difference. Major advantages of the orifice are that they have no moving parts and their cost does not increase significantly with the pipe size.

   Conical and quadrant orifice are relatively new. The units were developed primarily to measure liquids with low Reynolds numbers. Essentially constant flow coefficients can be maintained at R-values below 5000. Conical orifice plates have an upstream bevel, the depth and angle of which must be calculated and machined foe each application.

   Metering accuracy of all orifice flow meters depends on the installation conditions, the orifice area ratio, and the physical properties of the liquid being measured.

b. **Venturi tubes** have the advantage of being able to handle large flow volumes at low pressure drops. A venturi tube is essentially a section of pipe with a tapered entrance and a straight throat. As liquid passes through the throat, its velocity increases, causing a pressure differential between the inlet and the outlet regions.

These flowmeters have no moving parts and can be installed in large diameter pipes using flanged, welded or threaded-end fittings. Four or more pressure taps are usually installed with the unit to average the measured pressure. Venturi tubes can be used with most liquids, including those having high solids content.

c. **Flow tubes:** Flow tubes are somewhat Shimlar to venture tubes except that they do not have the entrance cone. They have a tapered throat, but the exit is elongated and smooth. The distance between the front face and the tip is approximately one half the pipe diameter. Pressure taps are located about one half pipe diameter downstream and one half pipe diameter upstream.

d. **Flow nozzles:** Flow nozzles at high velocities, can handle approximately 60 percent greater liquid flow than orifice plates having the same pressure drop.

e. **Pitot tubes:** Pitot tubes sense to pressure simultaneously, impact and static. The impact unit consists of a tube with one end bent at right angles towards the flow direction. The static tube's end is closed, but a small slot is located in the side of the unit. The tubes can be mounted separately in a pipe or combined in a small casing.

Pitot tubes are generally installed by welding a coupling on a pipe and inserting the probe through the coupling. Use of most pitot tubes is limited to single point measurements. The units are susceptible to plugging by foreign materials in the liquid. Advantages of pitot tubes are: low cost, absence of moving parts, easy installation and minimum pressure drop.

f. **Elbow meters:** Elbow meters operate on the principle that when liquid travels in a circular path, centrifugal force is exerted along the outer edges. Thus, when a liquid flow through a pipe elbow, the force on the elbow's interior surface is proportional to the density of the liquid times the square of its velocity. In addition, the force is inversely proportional to the elbow's radius. A 90 deg. pipe elbow can serve as a liquid flow meter.

g. **Target meters:** Target meters sense and measure forces caused by liquid impacting on a target or drag- disk suspended in the liquid stream. A direct indication of the liquid flow rate is achieved by measuring the force exerted on the target. In other words, the meter consists only of a hinged, swinging plate that moves outward, along with the liquid stream. In such cases the device serves as a flow indicator.

h. **Variable Area Flow Meters:** Variable area flow meters are offered primarily as reliable, low-cost in-line visual flow rate indicators with adequate versatility to monitor a wide range of industrial liquids and gases.

These simple in-line flow meters utilize the time-tested variable area technology, in which the velocity of the flowing fluid forces the (free moving) float, or piston to shift position, increasing or decreasing the size of the opening (variable area) to allow the fluid to pass.

The variable area flow meter is also a head-type flow sensor, but it does not measure the pressure drop across a fixed orifice; instead, the pressure drop is held relatively constant and the orifice area is varied to match the flow. In gravity type variable area flow meters, increasing flow lifts the float, piston, or vane and it's the weight of these flow elements that have to be balanced by the kinetic energy of the flowing stream. These units can only operate in vertical position. When the lifting of the float, piston or vane is resisted by the spring instead of gravity, the meter can be installed in any position.

There are three types of flow meters: Rotameter, Orifice/Tapered Plug Meters and Piston-type), using the variable area metering principle.

**i) Rotameter:** Rotameters are popular choices for low flow measurement due to their low cost, simplicity, low pressure drop, relatively wide rangeability, and linear output.

Rotameters are available which transmit pneumatic, electronic, or time pulse signals or provides recording, totalising and control functions.

Operating Principle: The Rotameter contains a float that is free to move vertically, within a tapered conical flow tube. As the flowing media moves upward through the annular area between the float and the expanding (tapered) metering tube, the float is lifted to a level of equilibrium at which the weight of the float is equal to the upward force of the fluid. The vertical rise (distance) of the float is proportional to the change in flow rate. The flow rate is indicated by visually checking the position of the float against a graduated flow scale, affixed to the outside of the tapered (transparent) tube.

**ii) Orifice and Tapered Plug Principle**

This type of flow meter uses a fixed orifice within a vertical meter enclosure. A tapered float (narrow at the bottom) is free to move up and down through the fixed orifice. The flow rate is indicated by observing the position of the float, relative to the orifice.

The tapered–plug variable area flowmeter are made with metallic meter bodies and are used on higher pressure applications, where errors of 5 to 10 % full scale can be tolerated. This is a type of variable area flowmeter that operates a piston in a perforated cylinder.

**iii) Piston-type Flow Metering Principle**

The EH55 Series Piston-type Variable Area Flow Meter uses a sharp-edged annular orifice, formed between the open-centered piston and a tapered metering cone. The piston is held in a "no flow" position at the base of the tapered cone by a calibrated retention spring. Flow through the meter creates a differential pressure across the piston orifice, moving the piston against the spring. The greater the volume, the further the piston moves.

Externally, the flow indicator ring is magnetically-coupled to the moving piston. A specific line on the indicator ring is visually "read" against a graduated flow scale mounted on the inside of the transparent dust guard.

## 5. Open channel meters

The "open channel" refers to any conduit in which liquid flows with a free surface. Included are tunnels, non pressurized sewers, partially filled pipes, canals, streams, and rivers. Of the many techniques available for monitoring open channel flows, depth related methods are the most common. These techniques presume that the instantaneous flow rate may be determined from a measurement of the water depth, or head. Weirs and flumes are the most widely used primary devices for measuring open channel flows.

**a. Weirs:** Weirs operate on the principle that an obstruction in a channel will cause water to back up, creating a high level (head) behind the barrier. The head is a function of flow velocity, and, therefore, the flow rate through the device. Weirs consist of vertical plates with sharp crests. The top of the plate can be straight or notched. Weirs are classified in accordance with the shape of the notch. The basic types are V- notch, rectangular and trapezoidal. The special case of a trapezoidal weir with side slopes of 1:4 is known as Cippoletti weir; this form leads to a simplified calculation. V-notch weirs generally have a notch angle from 30 degrees to 90 degrees depending on required flow capacity.

**b. Flumes:** Flumes are generally used when head loss must be kept to a minimum, or if the flowing liquid contains large amounts of suspended solids. Flumes are to open channel what venture tubes are to closed pipes. Popular flumes are the Parshall and Palmer-Bowlus designs.

The Parshall flume consists of a converging upstream section, a throat, and a diverging downstream section. Flume walls are vertical and the floor of the throat is inclined downward. Head loss through Parshall is lower than other types of open channel flow measuring devices. High flow velocities help make the flume self- cleaning. Flow can be measured accurately under a wide range of conditions.

Palmer-Bowlus flumes have a trapezoidal throat of uniform cross–section and a length about equal to the diameter of the pipe in which it is installed. It is comparable to the parshall flume in accuracy and its ability to pass debris without cleaning. A principle advantage is the comparative ease with which it can be installed in existing circular conduits, because a rectangular approach section is not required.

Discharge through weirs and flumes is a function of level, so level measurement techniques must be used with the equipment to determine the flow rates. Staff gauges and float operated units are the simplest device used for the purpose. Various electronic sensing, totalizing, and recording systems are also available.

A most recent development consists of using ultrasonic pulses to measure liquid levels. Measurements are made by sending sound pulses from a sensor to the surface of the liquid, and timing the echo return. Linearizing circuitry converts the heights of the liquid into the flow rate. A strip charter recorder logs the flow rate, and a digital totalizer registers the total gallons. Another recently introduced microprocessor based system uses either ultrasonic or float sensors. A keypad with interactive liquid crystal display simplifies programming, control and calibration tasks.

## 6. Size of the bulk water meter

The size of the water meter to be installed is governed by:

- The diameter of the pipe network;
- The flow rate of the pump (for cases where meter is installed in the pumping station).

The meter must be able to accurately record through the entire range of flows expected from the pump (even if the size of meter is lower than that of pipe). Therefore a water meter should be selected to ensure its rated operating conditions are never exceeded. Selecting a water meter that matches the optimal flow rate will increase the accuracy and life of the meter.

Generally the size of the water meter selected should match that of the pump outlet diameter and corresponding pipe. In circumstances where it is impractical to install a meter with the same diameter of the pipe, reducers with the correct size taper must be used.

It is acceptable to install a smaller diameter meter into existing pipe (provided that it can accurately record entire range of flows expected from pumps). The installation of a smaller water meter is conditional on the use of a 6 to 1 ratio taper followed by a straight length of pipe the same diameter as the meter and equivalent in length to at least ten times the meter diameter before of the meter. After the meter, a straight length of pipe equivalent to five times the meter diameter is required, followed by a 6 to 1 ratio taper back out to the existing pipe

(www.dwlbc.sa.gov.au/files/Installingyourmeter.PDF).

## Annexure 5.2b

# Selection of Water Meters

Water meters being available in many designs with different end-connections and varying flow characteristics, due consideration should be given when selecting any one type of meter for a particular situation.

Some of the selection criteria or the requisites are described below:

### Accuracy limits

The meter must be capable of meeting a standard of accuracy of ± 2%of actual flow over the expected range of the water pipeline system. This standard is to be met operating in either a horizontal or inclined pipeline system. The meter should be recognized by any agency of repute.

### Head loss

Installation of meter in a water supply system usually involve loss of pressure head, while selecting a meter it should be considered that the pressure loss is not significant.

### Materials

The meter should be made of sound, durable, corrosion resistant materials. The meters should have hermetically sealed dials. As in their absence there is ingress of moisture on the face of the dial and hence the meter becomes unreadable. Also ensure that all the parts of the meter that are in contact with water should be made of from materials that are non-toxic, non-reactionary and are biologically inert.

### Flow display unit

The meter should have an integrated flow display unit for the display of flow data. The flow display unit must be resistant to corrosion and fogging. It should be easily readable with clearly specified units and should be enable of determining the following parameters:

- Cumulative flow totaliser should be able to be expressed in Kilolitres (Kl) with a minimum of a six digit display, and
- Instantaneous flow rate able to be expressed in litres/second (l/s)

### Cost

Cost is a critical factor in the selection of any meter. While purchasing a water meter the operating cost should also be considered along with the capital and installation cost. Cost criteria should be considered with respect to the quality of meter.

### Flow direction

The meter should be labelled so as to show the direction of flow, orientation, and any other necessary installation information to achieve the required accuracy. The flow volume totalised must be unaffected by flow in the opposite direction to the labelled flow direction.

## Annexure 5.2c

# Installation Practices

Proper installation of meters is a must to measure the water flow accurately. It is often observed that installation of meters is guided by the available space and does not follow the prescribed norms for installation. As a result the alignment of the meters is also not as per the recommended procedures. Installation of meters may require slight changes in the existing alignment of pipes and a proper selection of location for installation. Installation requirements vary drastically among the various meter types. They can be the deciding factors in meter selection For example if a vertical pipe section is not found the variable area meter cannot be used instead inferential meters should be placed horizontally with the dial facing upwards.

### Domestic water meters

To ensure a proper working of the meters, meters should be installed as per the guidelines laid down by BIS, IS-2401: 1973, which are as following:

#### I. Location of meter

The meter shall be installed at a place where it is easily accessible for the purpose of periodical reading, inspection, testing and repairs. Usually, this means having no obstructions to reading the meter.

a. Water meters may be installed underground, either in the carriage way outside the premises or at a convenient place within the premises. In order to enable the meters to be accessible for periodical reading, inspection, testing and repairs, they shall be housed in water meter boxed conforming to IS: 2104-1962. Top of the meter box shall be placed at a slightly higher level than the surrounding ground level so as to prevent ground water entering in and flooding the chamber during rains and ensuring that the site remains free of mud and other obstacles and should not be installed deeper than 1.5 m below ground level. (as shown in Figure1)

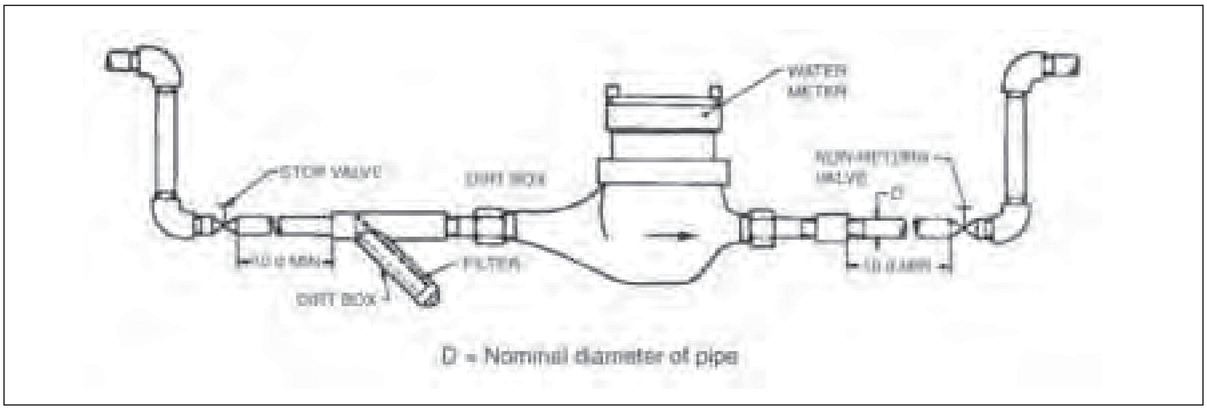
**Figure 1** A boxed water meter

**Source:** www.westvancouver.ca/upload/documents/water/meter_booklet.pdf

b. A meter shall be located where it is not liable to get severe shock of water hammer, which might break the piston or damage the rotor, and the meter position shall be such that it is always full of water a recommended method of making connection to achieve the purpose is shown in Figure 2.

   In some cases, straight pipe length of 10 diameters is used before and after the meter. However, it is better to refer to the installation practices suggested by the meter manufacturer for deciding exact location of the meter. Strainer is some cases are already built-in the meter.

c. There shall be straight lengths of pipes upstream and downstream of the meter so as to run out any turbulence produced by the presence of valves etc or changes in the pipe direction as the turbulent flow of water affects the accuracy of the meter.




**Source** : BIS, Indian Standard Code of practice for selection of domestic water meters, 1st revision, IS2401:1973

**Figure 2** Position of Domestic water meter

d. In the case of intermittent water supply system a meter should always be installed so that the top of the meter is below the level of communication pipes so that meters always contains water, when there is no supply of water. This avoid the damages and over run of the meter, also the minimum straight length conditions should also be followed.

**II. Installation of meter**

a. If the meter body or the adjacent pipes become partially drained of water, the accumulated air, when passed through the meter, is registered as water, and may cause inaccuracies and perhaps damage. The inaccuracies may be more pronounced in the case of inferential meters.

   In such situations suitable devices like air-release valve may be fitted on the upstream side of the meter. In the case of intermittent water supply system, where there are frequent changes of air locks, the piston of the semi-positive meter often breaks. In such a case, it is advisable to ensure that the top of the meter is below the level of the communication pipe.

b. A meter shall not run with free discharge to atmosphere. Some resistance should be given in the downside of the meter if static pressure on the main exceeds 10m head.

c. Semi-positive meters may be fixed in any position, with the dials facing upwards or sideways, and they may be installed in horizontal or vertical pipe without affecting wearing properties of accuracy at normal service flows. Where backward flows are anticipated, reflux valves or NRVs should be provided. A stop valve should also be provided on the upstream side as shown in figure2 to isolate the meter, for repair or calibration, whenever necessary.

d. Inferential meters shall be installed in horizontal position with their dial facing upwards. However, water meters are to be installed in vertical pipelines, details shall be as agreed to between the manufacturer and the purchaser.

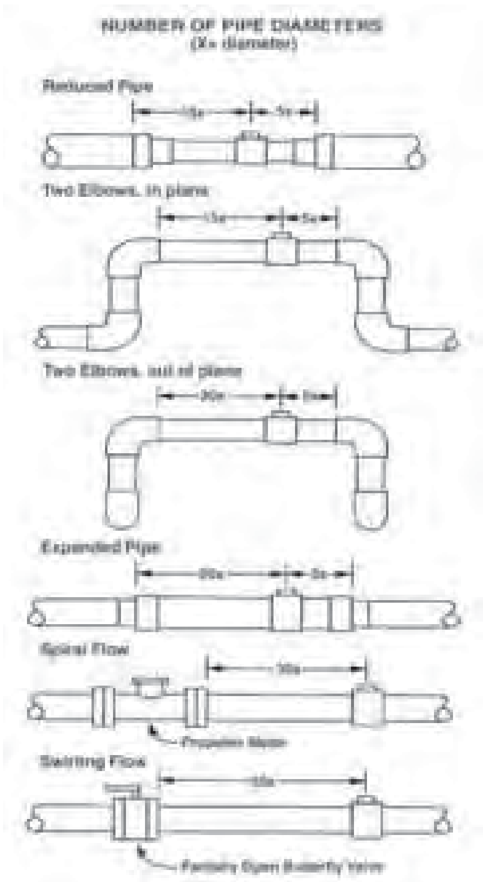



**Figure 3** Different alignments for positioning of flow meter

**Source:**
www.seametrics.com/pdf/3straightrun.pdf

Before installing a meter, the section of line to be metered shall be thoroughly washed flushed to remove all foreign matter and, when starting up, control valve shall be opened slowly until the line is full, as a sudden discharge may damage the meter.

e. The meters and the connecting pipes shall be strongly supported for protection of the meters and to avoid noisy vibration.

### Bulk water flow meters

Flow meters (like electromagnetic, Ultrasonic etc.) are usually used on larger pipelines, which are mostly filled with water. These pipelines can be gravity mains, transmission mains or any major bulk supply line.

The meter is installed in the pipeline using flanged or threaded connections giving due consideration for conditioning sections. It should be seen that stress-free installation is carried out in pipeline. It is essential to install the flow meter co-axially to the pipeline without protruding any packing or gasket into the water flow stream.

An extreme example is a pipeline, which cannot be shut down, or the measurement point bypassed. In such a case, a clamp on meters should be used, such as Dopplers' and cross correlation. Even if it is not necessary to install the meter without a shutdown, the installation requirements are still important factors both with regard to cost and plant acceptability. It might be the case that, the requisite straight pipe lengths are not available and it is then necessary to de-rate the performance or consider an alternative meter type, such as an electromagnetic one having a minimal requirement for straight upstream piping.

Specific application requirements affect different meters in different ways. Unavailability of an electricity supply at the measurement point eliminates the electromagnetic flow meter after consideration. If a vertical pipe section cannot be found, the variable area meter cannot be used. A positive displacement meter requires a strainer, and so on. Even if the meter installation can be met, their effect on the overall system cost should still be considered and quantified.

### Poor installations

Poor installations are mainly due to lack of knowledge of installation practices or due to constraints in installation. Some examples of poor installations are given here.

### Good Installations

Nearly all the flow meters must be installed so that there is a significant run of straight pipe before and after the location of the flow meter. This is intended to allow the straight pipe run to "smooth out" any turbulence produced by the presence of valves, bends and changes in pipe direction. This type of turbulence produces error in the reading of most flow meters.

The straight length required for the mechanical meters is generally shorter than for other meter types. It is generally accepted that a mechanical meter requires a straight pipe length of 3 diameters and there should be no direct obstructions immediately after the meter – i.e., the meter should not be bolted directly onto a valve or strainer etc.

#### *Installation requirements for electromagnetic flow meters*

- An upstream/downstream straight length of at least 5 DN/3 DN (nominal diameter) at least is recommended to take advantage of claimed accuracy performances. These meters can be installed in horizontal pipelines, vertical pipelines, or the sloping lines, but it is essential to keep the electrodes in the horizontal plane to assure uninterrupted contact with the water.

A very poor installation!
Bends in both the horizontal and vertical plane

Insufficient straight pipe perfect air trap

- Tapers to be selected for installation on bigger piping diameter should always have a top angle below or equal to 8°.
- In gravity feed systems, the meter must be kept full therefore; flow meter should always be installed at the lowest point of the horizontal pipeline, or in vertical up flow line.

***Installation requirements for ultra sonic flow meters***

For both Doppler and transit-time flowmeters to indicate true volumetric flow rate, the pipe must always be full. A Doppler meter on a partially full pipe, however, will continue to indicate flow velocity as long as the transducers are both mounted below the liquid level in the pipe.

The minimum distance that the meter must be from valves, tees, elbows, pumps, and the like, both upstream and downstream is usually expressed in pipe diameters and typically should be 10 diameters upstream and 5 diameters downstream.

Clamp-on meters typically require that the thickness of the pipe wall be relatively small in relation to the distance the ultrasonic energy must pass through the measured liquid. As a general rule, the ratio of pipe diameter to wall thickness should be >10:1; i.e., a 10 in. pipe should not have a wall thickness >1 in.

Each of the different ultrasonic flow meter design has its own unique installation requirements; the manufacturers' specific recommendations should therefore be adhered to when installing the flow meter.

Meter too close to the dirt box and bends

**Source:** Sensus Metering Systems : South Africa

## Annexure 5.2d

# Calibration of Water Flow Meters

Calibration involves comparing the meter's display with the measured volume. The particular method of calibration that is most suitable depends primarily on the required accuracy. A meter suspected to be malfunctioning is also tested for its accuracy of measurement. The testing is done as per IS6784: 1996 /ISO4064 part III.

### Need for calibration

Flow calibration is essential to:

a. Maintain the accuracy of meters, which diminishes with time (due to wear and tear in case of mechanical meters, while ultrasonic and electromagnetic meters may experience reduced signal strength reception or transmission).

b. Confirm performance of the flow meter: A reliable dataset would provide a robust platform to carry out water audits.

c. Comply with statutory or legal requirements.

d. Provide traceability of measurement and confidence in recorded data.

### When should the meters be calibrated

Calibration should be carried out regularly, at an interval of broadly two years so as to meet the required accuracy norms for the flow metered. This is because meters drift with time, depending on factors such as operating conditions, the medium, the type of meter and how often it is used. It is often a good idea to plan ahead for regular calibrations over a longer period of time.

There are two philosophies of flow meter calibration. One is that it is better to have a fixed calibration system with all the associated technical back up and with the flow meters being brought to the calibration system, the other favours calibrating in situ leaving the flow meters in their installed condition and using a portable calibrator. The former will generally provide the more accurate calibration but the latter has the advantage that site-specific effects such as proximity to hydraulic disturbances can be taken into account. It is necessary to decide carefully to adopt the option.

There is often no choice but to carry out in situ calibration where

a. Flow cannot be shut off

b. Site-specific conditions will have to be accounted for

c. The meter is so large that removal; transport and testing costs would be prohibitive.

The major constraint with in situ calibration technique is that the high accuracy laboratory calibration cannot be matched in the field and accuracies of ± 2% to ± 5% is all that can be achieved and such field tests are

The metering accuracy testing is carried out at Qmin, Qt, and Qmax. separately where:

Qmin. : Lowest flow rate at which the meter is required to give indication within the maximum permissible tolerance.

Qt: the flow rate at which the maximum permissible error of the water meter changes in value.

Qn: Half the maximum flow rate.

Qmax.: The higher flow rate at which the meter is required to operate in a satisfactory manner for short periods of time without deterioration.

The accuracy of the flow meter is divided into two zones i.e.

(1) Lower measurable limit in which ±5% accuracy from minimum flow to transitional flow (exclusive)

(2) Upper measurable limit in which ±2% accuracy from transitional flow (inclusive) to maximum flow.

called confidence checks rather than absolute calibrations. Such checks are often the precursor to removal of flow meter for laboratory calibration or replacement.

## Methods of calibration

The calibration of flow meters is done both in situ as well as in the laboratory.

> For field test following methods can be used:
> - ❖ Clamp on devices
> - ❖ Thermodynamic method
> - ❖ Velocity area methods (insertion meters)
> - ❖ Tracer methods

1. In situ calibration methods: The methods involved in the in situ calibration are insertion-point velocity and dilution gauging/tracer method.

a. **Insertion-point velocity:** This method of the in situ flow meter calibration utilizes point velocity measuring devices where the calibration device chosen is positioned in the flow stream adjacent to the flow meter being calibrated and such that mean flow velocity can be measured. In difficult situations a flow traverse can be carried out to determine flow profile and mean flow velocity.

b. **Dilution gauging/tracer method:** This technique can be applied to closed pipe and open channel flow meter calibration. A suitable tracer (chemical or radioactive) is injected at an accurately measured constant rate and samples are taken from the flow stream at a point downstream of the injection point where complete mixing of the injected tracer will have taken place. By measuring the tracer concentration in the samples the tracer dilution can be established and from this dilution and the injection rate the volumetric flow can be calculated. Alternatively a pulse of tracer material may be added to the flow stream and the time taken for the tracer to travel a known distance and reach a maximum concentration is a measure of the flow velocity.

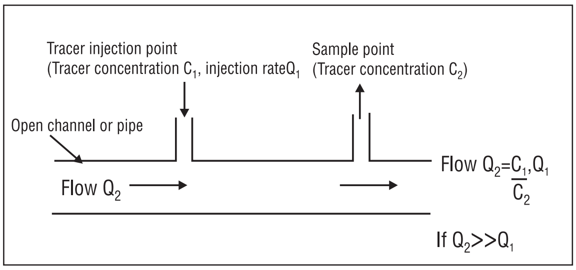



**Figure 1** Dilution gauging by tracer injection

**Source:** BE Noltingk, Jones' instrument technology volume 1, mechanical measurements

2. **Laboratory calibration methods:** The methods used in the laboratory for the calibration of the flow meter are: Collection method, prover technology, and master meter or reference meter. Details of the methods are described below:

**a. Collection method (Gravimetric/ volumetric)**

- **Volumetric method:** In this technique, flow of liquid through the meter being calibrated is diverted into a tank of known volume. When full this known volume can be compared with the integrated quantity.
- **Gravimetric method:** In this technique, the flow of liquid through the meter being calibrated is diverted into a vessel that can be weighed either continuously or after a pre-determined time; the weight of the liquid is compared with the registered reading of the flow meter being calibrated.

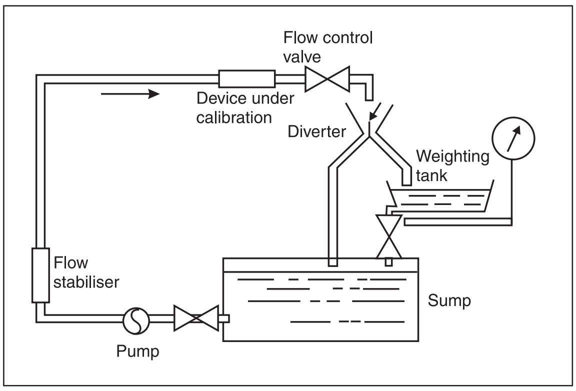



**Figure 2** Flow calibration by weighing

**Source:** BE Noltingk, Jones' instrument technology volume 1, mechanical measurements

b. **Prover:** This device is also known as a "meter prover". It consists of a U-shaped length of pipe and a piston or elastic sphere. The flow meter to be calibrated is installed on the inlet to the prover and the sphere is forced to travel the length of the pipe by the flowing liquid.

   Switches are inserted near both ends of the pipe and operate when the sphere passes them. The swept volume of the pipe between the two switches is determined by initial calibration and this known volume is compared with that registered by the flow meter during calibration.

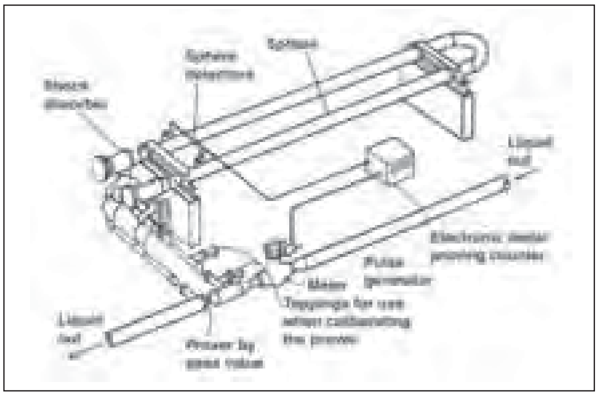


**Figure 3** Pipe prover

**Source:** B E Noltingk, Jones' instrument technology volume 1, mechanical measurements

c. **Master or reference meter:** For this technique a meter of known accuracy is used as a calibration standard. The meter to be calibrated and the master meter are connected in series and are therefore subject to the same flow regime. To acquire consistent accurate calibration it should be ensured that the master meter is itself subjected to periodic recalibration.

### Government Agencies providing accreditation

Normally the manufacturers of the flow meters provide laboratory calibration of the flow meters in their works. Some of the government agencies also provide laboratory calibration vis. Fluid Control Research Institute (FCRI), Palaghat, Central Water and Power Research Station (CWPRS), Pune and Institute for Design of Electrical Measuring Instruments (IDEMI), Mumbai.

**Annexure 5.3**

# Database Generation for Bangalore City in GIS

The Bangalore water supply and sewerage systems have grown enormously during the last four decades. In order to handle such a large system with large volumes of geographically related information, it was imperative to develop and give decision makers a powerful management and decision-making tools. The aim of the BWSSB GIS project consisted of setting up a Geographical Information System for Water Supply and Sewerage. The key business objectives driving the need for a corporate GIS were as follows:

- to provide interactive access to up-to-date network and geographical information.
- for Operations and Maintenance purposes;
- to provide a planning tool to enable the acquisition of new & replaced main;
- to provide accurate and comprehensive network information for monitoring.
- reporting, decision making and data consolidation;
- to allow the integration of geographical information from different sources;
- scales, both internal & external;
- to provide a widely available asset management system;
- To set up a pilot repository spatial dataset for the BWSSB.

The development of a total GIS Solution involves:

- BISON (Bangalore Information System On Network) Export. This is the repository whose updation depends on the maintenance of the data since the repository is by definition the data sharing tool which benefits all users.
- BISON Light is looked at as a combination of three tools in a user-friendly environment that doesn't require strong computer knowledge, but at the same time offers a wide range of capabilities.
- BISON Visio allows the user to display and to query all the different water supply and sewerage layers in a smooth and easy way. It will offer consultation of interactive maps dealing with SS concerns, and provide hard & soft copies of maps in all kinds of scale.
- BISON Editor constitutes the core tool for the updation process. It deals with point data at the Service Station level: consumers, complaints & repairs, water quality.
- Management Indicator Panel (MIP): This product was defined in order to provide a document that will give the key persons at the decision making level information at a glance of the entire assets of the BWSSB through a series of maps and important indicators. Its main targets are the Chief Engineers and the Chairman. Customized Tools providing a comprehensive GIS solution for the BWSSB.

## Conceptual Data Model of BISON

1. Area covered: A 290 Sq. Kms pilot area, covering the whole BWSSB jurisdictions area to implement the GIS system

2. Base Maps: The digital vector data and maps based on aerial photography for the pilot area were provided by National Remote Sensing Agency

3. Detailed water supply and sewerage systems analysis

   a. Compilation and synthesis of available information

   b. Identification of information gaps

   c. Acquisition of the basic knowledge to conduct the DMA

   d. Study of BWSSB organization

   e. Detailed description of procedures followed by BWSSB

   f. Preliminary stage for GIS and Database design

This crucial step was undertaken to ascertain the requirements of BWSSB. The main objectives were:

- To assess what BWSSB expects from the GIS
- To assess how BWSSB will utilize the GIS in order to design a GIS that supplements these
- To carry out a detailed analysis of BWSSB's
- To inform BWSSB what their expectations really mean in term of data collection, data integration, data updation. required equipment, staff availability and training on a long term
- To select the needs that can be fulfilled within the current project, the needs that can be fulfilled during a project extension and the needs that can only be fulfilled later 1:2000 scale NRSA maps delivered by NRSA
- To arrive at a mutual consensus on the implementation of the selected user needs and to tailor a customized GIS

## GIS Design AND Coding: Implementation of the MERISE method

- Conceptual Data model for definition and relations between all data required for the application
- Conceptual Organization and Process Model for elaboration of processes necessary to fulfill the selected needs
- Logical Data Model for definition of logical links between tables designed in the Conceptual Data Model
- Functional Architecture designs which sites have to be equipped according to the above organization and design
- Physical Data Model, a collection of scripts building the entire structure of the
- Oracle database, that was designed according to the above requirements
- Design of User Interfaces such as application menus, toolbars, popup and windows, as it will be seen by the users
- Operational Process Model for details of procedures codlings
- ("Development and testing of front-end application")

### Graphical and Alphanumerical

Data Collection:290 sq. kms spread over the five divisions of BWSSB Maintenance

Department 55 Services Stations

- Over 4000 kms of water pipelines
- Over 3000 kms of sewage lines
- Over 3.2 lakh consumer connections

### Data Integration

- Data Entry of Alphanumerical Data using Excel sheets
- Report of Graphical data collected on the field on reference base maps (Ao size-1:1200 scale)
- Conversion of NRSA base maps into the ARCINFO /ARCFM GIS
- Digitization of Graphical data ARCINFO conversion after Quality Control
- Corrections and validation by BWSSB
- Final Integration of Data after Topology Building
- Development and Testing of Front End Application
- Development of User Interfaces to fulfill BWSSB Needs and procedures of their functioning
- Coding in VB (Visual Basic) and VBA (Visual Basic for Applications) to implement the Application Modules for the users
- The Employee database along with the Billing system integration in the GIS improves the Bill collection and the transparency among the organization.
- Accessible from the 55 Service Stations, Bison
- Editor provide a powerful solution to track the complaints & repairs and to manage the water quality and the new consumer
- A comprehensive information collected all over the networks
- Procedure Level as well as Global Testing to ensure strict Quality Controls

### Training of BWSSB Staff

- Identification and Selection of Trainees
- On-the-job Training to BWSSB Services Station staff during field Surveys
- Categorized Training to various users according to proposed usage (updation, viewing etc.)
- Training to Decision Makers as well as the Operational Staff

### Duration of Project

- 29 months: official project start was may 2000, end in November 2002

**Staffing**

- 1 GIS Senior Expert as Term Leader with a Water Management background,
- 1 co-Term Leader, GIS and Database expert,
- 1 GIS Design Engineer (expert)
- 1 Hydraulic, Water supply and Waste Water Expert ,
- 4 GIS developers (Control Data Collection – Data Integration – GIS Map Integration, ARC Info , MAP Object)
- 1 Database manager +one Database expert (ORACLE+SDE), 4VB, VBA, Developers, 4 digitizers, 30 surveyors.
- Budget-the project finance under the Indo-French Protocol
- Hardware & software : INR 1.5 Crores,
- Services charges for GIS implementation & maintenance : INR 8.7 Crores
- Two months of training for 60 persons, extensively in the use of BISON and the benefit from the data standardization.

## Annexure 6.1

# Existing Tariff Schedules in Chennai, Bangalore and Delhi

### Chennai

| Category | Qty. of water | Rate/KL (in Rs.) | Minimum rate chargeable (including sewerage charges) (in Rs.) |
|---|---|---|---|
| **Domestic** | | | |
| *Residential* | upto 10 KL | 2.5 | 50/- per month per dwelling unit |
| (i) Domestic Residential premises (other than flats or block or line of houses) | 11 to 15 KL | 10 | |
| | 16 to 25 KL | 15 | |
| | Above 25 KL | 25 | |
| (ii) Flats or houses in a block of flats or line of houses respectively used wholly for residential purposes | upto 10 KL | 2.5 | 50/- per month per flat |
| | 11 to 15 KL | 10 | |
| | 16 to 25 KL | 15 | |
| | Above 25 KL | 25 | |
| (iii) Individual flats or houses in a block of flats or line of houses respectively used for other than residential purposes | Partly commercial – Rs. 150/- p.m. per flat | | |
| | Non water intensive – Rs. 400/- p.m. per flat | | |
| | **Water intensive** – Rs. 650/- p.m. per flat | | |
| | Private hospital – Rs. 800/- p.m. per flat | | |
| | **Institutional** – Rs. 300/- p.m. per flat | | |
| | Pvt. Educational Instn. – Rs. 400/- p.m. per flat | | |

| | | | |
|---|---|---|---|
| **B. Commercial** | Private hospital – upto 500 KL<br>Rs. 50/KL | | Rs. 800/- * (Water Intensive) |
| | All others upto – 500 KL<br>Rs. 35/KL | | Rs. 400/- (Non-water intensive) |
| | Private hospital – above 500 KL<br>Rs 80/KL for entire quantity | | Rs. 800/- *(Water intensive) |
| | All others – above 500 KL<br>Rs. 60/ KL for entire quantity | | Rs. 650/- * (Water intensive) |
| **C. Partly Commercial** | Upto 10 KL | Rs. 5 | |
| | 11 to 15 KL | Rs. 15 | Rs. 150 |
| | above 15 KL | Rs. 25 | |
| | | | Rs. 400 |
| **D. Institutional** | 1) Pvt. Edn. Institution | Rs. 40.00/KL entire quantity | Rs. 200 |
| | 2) Govt. Hospital | Rs. 20.00/KL entire quantity | Rs. 300 |
| | 3) All others | Rs. 30.00/KL entire quantity | |
| **E. Municipal bulk supply** | Entire consumption | Rs. 15 | – |
| **E (I) Municipal bulk supply** | Entire consumption | Rs. 7.00 (wherever local bodies met the cost of infrastructure) | – |

* Sewerage charges 25% on water supply charges wherever sewer connections are provided.
* Water intensive means premises used fully or partly as theatres, hotels, boarding houses, lodges, clubs, private hospitals, private hostels, kalyanamandapams, clinics with inpatient facility, swimming baths, places for keeping animals, vehicle service stations, nurseries.

| | | |
|---|---|---|
| i. | Hydrant and public fountains | Rs. 400/- per month including maintenance charges |
| ii. | Maintenance charges | |
| **F.** | 1) Mobile water supply to slums | Rs. 4/- per 1000 litres for entire quantity supplied |
| | 2) Maintenance charges for steel tanks | Rs. 200/- per month per tank |
| **G. Casual water supply** | | |
| **Mobile water supply to customers** | | |
| i. Domestic (including hostels of colleges and schools recognised by state/central govt./ govt. Qtrs. etc.) | Rs. 400 per load of 6000 litres/- Rs. 600/- per load of 9000 litres/ Rs. 670/- per load of 10000 litres | |
| ii. Partly commercial | | |
| a) Domestic purpose | Rs. 400/- per load of 6000 litres/Rs. 600/- per load of 9000 litres/Rs. 670/- per load of 10000 litres | |
| b) Other than domestic purpose | Rs. 510/- per load of 6000 litres/Rs. 765/- per load of 9000 litres/Rs. 850/- per load of 10000 litres | |
| iii) Commercial (including private hospital) | Rs. 510/- per load of 6000 litres/Rs. 765/- per load of 9000 litres/Rs. 850/- per load of 10000 litres | |

| | |
|---|---|
| iv) Institutional | |
| a) Private educational institution including hostels | Rs. 510/- per load of 6000 litres/Rs. 765/- per load of 9000 litres/Rs. 850/- per load of 10000 litres |
| b) Govt. offices/schools/colleges/hospitals etc. | Rs. 400/- per load of 6000 litres/Rs. 600/- per load of 9000 litres/Rs. 670/- per load of 10000 litres |
| v.) Water supply at Metro water filling points | |
| a) Domestic (including govt. schools/colleges/office institutions/ hospitals) | Rs. 400/- per 1000 litres |
| b) Commercial (including private hospitals/private educational institutions) | Rs. 60/- per 1000 litres |
| vi.) For the employees of the Chennai Metropolitan Water Supply and Sewerage Board who desires to avail the lorry water supply for their own house hold requirements, the cost will be calculated at actual cost price | Rs. 200/- per load of 6000 litres<br>Rs. 300/- per load of 9000 litres |
| **H. Hire charges for tanks hired out** | Rs. 250/- for two days and Rs. 50/- for every additional day |

| Unmetered consumer tariff | Water charges/Month (including sewerage charge) |
|---|---|
| **Category** | |
| A. Residential | |
| (I) Domestic residential premises (other than flats or block or line of houses) | Rs. 50/- p. m. per dwelling unit |
| (ii) Flats or houses in a block of flats or line of houses respectively used wholly for residential purposes | Rs. 50/- p. m. per flat |
| (iii) Individual flats or houses in a block of flats or line of houses respectively used for other than residential purposes | Partly Commercial Rs. 150/- p.m. per flat |
| | Non water intensive Rs. 400/- p.m. per flat |
| | Water intensive (all others) |
| | Rs. 650/- p.m. per flat |
| | Private Hospital Rs. 800/- p.m. per flat |
| | Institutional Rs. 300/- pm. per flat |
| | Pvt. Educational Instn. Rs. 400/- p.m. per flat |
| B. Commercial | **Water intensive** |
| | Private Hospital Rs. 800/- p.m<br>All others Rs. 650/- p.m. |
| | Non water intensive<br>All others Rs. 400/- p.m. |
| C. Partly Commercial | Rs 150 p. m. |
| D. Institutional | I) Pvt. Educational Institution – Rs. 400/- p. m. |
| | ii) Govt. Hospital – Rs. 200/- p. m. |
| | iii) All others – Rs. 300/- p. m. |
| E. Public supply tubewell pumps or mark II pumps | Rs. 40/- p. m. |

## Bangalore

| **Domestic (filtered water)** | | | |
|---|---|---|---|
| | **Category and Consumption (KL)** | **Rs/KL** | **Minimum charges (in Rs.)** |
| I. Domestic (Section 36[1]) | | | |
| | 1) 0 – 8000 | 6.00 | 48.00 |
| | 2) 8001 – 25000 | 9.00 | 201.00 |
| | 3) 25001 – 50000 | 15.00 | 676.00 |
| | 4) 50001 – 75000 | 30.00 | 1326.00 |
| | 5) 75001 – 100000 | 36.00 | 2226.00 |
| | 6) 100001 & above | 36.00 | 5826.00 |
| | Sanitary charges for domestic connection | (I) Rs. 15.00 at flat rate for consumption of 0 to 25000 liters | |
| | | (ii) From 25001 to 50000 liters 15% on water supply charges per month | |
| | | (iii) 20% of water supply charges per month against for consumption of above 50000 liters | |
| II. Non-domestic | | | |
| | 1) 0 – 10000 | 36.00 | 360.00 |
| | 2) 10001 – 20000 | 39.00 | 390.00 |
| | 3) 20001 – 40000 | 44.00 | 880.00 |
| | 4) 40001 – 60000 | 51.00 | 1002.00 |
| | 5) 60001 – 100000 | 57.00 | 2280.00 |
| | 6) 100001 & above | 60.00 | NA |

| | | | |
|---|---|---|---|
| **Industries** | | Rs. 60.00 | |
| III | Bidadi Industrial Area | Rs. 51.00 | |
| IV | Lorry loads | Rs. 250.00 | |
| V | Swimming pools | Rs. 60.00 | |
| VI | Public taps Section 36 VII | Rs. 3000.00 | |
| Sanitary charges | | | |
| I | Domestic connection | Rs. 15/- at flat rate for consumption of 0 to 8000 liters and 8001 to 25000 liters | |
| | | Rs. 15% of water supply charges per month for consumption of above 25000 liters upto 50000 liters | |
| | | Rs. 20% of water charges per month for consumption of above 50000 liters | |
| II | All non-domestic connection | From 10% to 20% of water charges for month | |
| III | For premises having water supply and UGD connection but supplementing water supply for tanker/borewells Bidadi Industrial Area | | |
| | a. Domestic and apartment | Rs. 50/- per month per individual house per flat. Revised from Rs. 200 to 300 per month per HP of borewell | |
| | b. Non-Domestic | | |
| IV | Premises not having water supply connection from BWSSB but having only UGD connection in addition to sanitary charges | Rs. 300/- per month | |

| | | | |
|---|---|---|---|
| V | Hotels having boarding and lodging supplementing water supply by tankers in addition to borewells | | |
| | (I) Non star hotels | Rs. 1000/- per month | |
| | (ii) 3 star hotels and above | Rs. 3000/- per month | |
| | (iii) 5 star hotels and above | Rs. 10000/- per month | |
| VI | For hospitals/nursing homes supplementing water supply by tankers in addition to borewell | | |
| | (I) Nursing home & hospitals having 100 beds | Rs. 2500/- per month | |
| | (ii) Hospitals/nursing homes having more than100 beds | Rs. 5000/- per month | |

## Delhi

| Category I (Domestic) | | Category II (Commercial) | | Category III (Industrial) | |
|---|---|---|---|---|---|
| **Consumption (per month)** | **Rs. (B) per KL.** | **Consumption (per month)** | **Rs. (B) per KL.** | **Consumption (per month)** | **Rs. (B) per KL.** |
| Upto 6 KLs | 0 | Upto 25 KLs | 10.00 | Upto 25 KLs | 15.00 |
| 7 – 20 KLs | 2.00 | Above 25 KLs and upto 50 KLs. | 20.00 | Above 25 KLs and upto 50 KLs. | 25.00 |
| 21– 30 KLs | 7.00 | Above 50 KLs | 30.00 | Above 50 KLs and upto100 KLs. | 35.00 |
| Above 30 KLs | 10.00 | | | Above 100 KLs. | 50.00 |

The second part of the tariff is volumetric Water Charges is based on actual consumption and to be calculated as 1.5 B X

Hence, the bill will be calculated as follows :

1. **P= M + 1.5 B X Where, M= Minimum service Charges**

B= Block tariff rates per KL.

X= Units consumption in KL.

P = Total Bill.

- M =Minimum service charges (Rs.)
- B= Block tariff rate per KL (Rs./KL.)
- X= Units consumed in KLs. (Number)

2. 50% of water consumption charges is towards sewerage maintenance.
3. In addition, water cess charges shall continue to be recovered at the previous rate of 2-paise per KL. till revised by the Central Govt./ DJB.
4. Meter Maintenance (Rent) charge @ Rs. 10.00 p.m. in case of DJB supplied water meters after expiry of warranty period.

# Annexure 6.2

## Formats for database

### 1) Category-wise annual income from water tariff

| S. No. | Customer Category (as per tariff structure) | Ferrule Size (as per tariff structure) | No. of Consumption | Yearly Connections | Fixed charge | Variable charge | Revenue from fixed charge | Revenue from variable charge | Total Revenue |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9=7+8 |
| | Category 1, e.g., Domestic | | | MLD | Rs/Month | Rs/KL | Rs Crore | Rs Crore | Rs Crore |
| | | 1/2" | | | | | | | |
| | | 3/4" | | | | | | | |
| | | 1" | | | | | | | |
| | | Any other size | | | | | | | |
| | Category 2, e.g., Non-Domestic | 1/2" | | | | | | | |
| | | 3/4" | | | | | | | |
| | | 1" | | | | | | | |
| | | Any other size | | | | | | | |
| | Category 3,e.g., Industrial | 1-1/2" | | | | | | | |
| | | 2" | | | | | | | |
| | | 3" | | | | | | | |
| | | 4" | | | | | | | |
| | | Any other size | | | | | | | |
| | Category 4,e.g., Public Standpost | | | | | | | | |
| | Category 5,e.g., Worship Places | | | | | | | | |
| | Category 6,e.g., Bulk | Consumer 1 | | | | | | | |
| | | Consumer 2 | | | | | | | |
| | | Consumer 'n' | | | | | | | |
| | Total | | | | | | | | |

## 2) Revenue–expenditure components

### Revenue

| S.No | Particulars | Previous Financial Year | Current Financial Year |
|---|---|---|---|
| I. | Revenue from sale of Water (in a particular Financial Year) | | |
| a. | Category I | | |
| b. | Category II | | |
| c. | Category III | | |
| d. | Category 'n} | | |
| II. | Revenue from subsidies & grants | | |
| | Source I: | | |
| | Source II: | | |
| | Source III: | | |
| | Source 'n' | | |
| III. | Loans from Government/Funding Agencies/Financial Institutions | | |
| | Source I: | | |
| | Source II: | | |
| | Source III: | | |
| | Source 'n' | | |
| IV. | Other Income | | |
| a | Metering | | |
| b | Road Cutting Charges | | |
| c | Income from regularization of connections (Illegal to legal) | | |
| d | Income from Water Tankers | | |
| e | New Water Connections | | |
| | **Total Revenue** | | |

## Expenditure

| S.No | Particulars | Previous Financial Year | Current Financial Year |
|---|---|---|---|
| **I.** | **Employee Cost – Permanent & Temporary** | | |
| a. | Salaries | | |
| b. | Overtime | | |
| c. | Dearness Allowance | | |
| d. | Bonus | | |
| e. | Medical Expenses Reimbursement | | |
| f. | Leave Travel Encashment | | |
| g. | Staff Welfare Expenses | | |
| h. | Other Employee Cost Items, if any: | | |
| II. | **Operation & Maintenance:** | | |
| a. | Plant & Machinery | | |
| b. | Pump Repair | | |
| c. | Repair of Pipelines | | |
| d. | Maintenance of Tanks | | |
| e. | Electricity Arrangements – Pumping & Treatment | | |
| f. | Other O&M Expense Items, if any | | |
| III. | **Administration & General Expenses** | | |
| a. | Rent, rates and taxes | | |
| b. | Legal Charges | | |
| c. | Audit Fees | | |
| d. | Conveyance & Travel Charges | | |
| e. | Insurance | | |
| f. | Consultancy Charges | | |
| g. | Technical Fees | | |
| h. | Other Professional Charges | | |
| i. | Electricity charges for office, building etc | | |
| j. | Other A&G Charges such as Books & Periodicals, Printing & Stationery, Entertainment of Officials etc. | | |
| | | | |

| | | | |
|---|---|---|---|
| IV. | **Expenditure on New Works** | | |
| a. | Expense Item I | | |
| b. | Expense Item II | | |
| c. | Expense Item III | | |
| d. | Expense Item 'n' | | |
| V. | **Interest & Finance Charges** | | |
| a. | Source I, rate of interest | | |
| b. | Source II rate of interest | | |
| c. | Source III, rate of interest | | |
| d. | Source 'n', rate of interest | | |
| e. | **Public Health & Engineering Department** | | |
| f. | Expense Item I | | |
| h. | Expense Item II | | |
| i. | Expense Item III | | |
| j. | Expense Item 'n' | | |
| | **Total Expenditure** | | |

To ensure financial clarity and transparency, the Waterworks Department should maintain separate accounts for each financial year. In other words, it should mention the revenue arrears and outstanding expenses separately and not aggregate them with revenue-expenditure in current financial year.

### *Billing & Collection Reports*

<table>
<tr><th>Month</th><th colspan="2">Current Billing Cycle</th><th colspan="2">Cumulative (During the entire Financial Year)</th></tr>
<tr><td>Billing<br>Category I<br>Category II<br>Category III<br>Category 'n' (As per tariff schedule)</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Total</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Collections<br>Category I<br>Category II<br>Category III<br>Category 'n' (As per tariff schedule)</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Total</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td></td><td>Total value</td><td>0-30 days</td><td>30-90 days</td><td>Above 90 days</td></tr>
<tr><td>Accounts receivable<br>Category I<br>Category II<br>Category III<br>Category 'n' (As per tariff schedule)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td></td><td></td></tr>
</table>

## Annexure 7.1

# Rationale for Reforms in urban water supply sector

### Investment Requirements

Public expenditure on urban water supply and sanitation accounts for 1.2% to 1.8% (10th Five Year Plan/latest figures) of the total plan investments, and is significantly short of requirements. For example, notwithstanding an aggregate budgetary investment of Rs. 243.41 billion in the urban water and sanitation sector over the successive five year plans investment gaps are large. According to estimates of the Rakesh Mohan Committee total requirement for urban infrastructure development covering backlog, new investments and O&M costs for the next ten years is Rs. 2,50,000 crores (US$ 57 Billion). The ninth Plan proposal identifies only around Rs. 12000 crores. With anticipated growth in Tenth plan providing additional funds of Rs.13,000 crores, the total expected plan outlay comes to Rs. 25,000 Crores (US$ 5.7 Billion) which is one tenth of the project requirements.

A direct consequence of inadequate provision is manifested in sharp deterioration of service levels. Economic and social costs of under-provision of water are also assessed to be extremely high. (Mathur,www.fiscalconf.org/papers/mathur.pdf)

To meet the huge requirements of funds for the improving infrastructure the urban local bodies thus need to look at alternate source of funding which may include external donors/banks (World Bank, OECF, ADB , DFID etc) or institutional investors like HUDCO/LIC etc. Further in the long term the municipal corporation may also need to tap funds from the markets by using instruments such as municipal bonds or by tapping funds from commercial banks. As a prerequisite to tapping these extra source of funding it may be necessary for the local bodies to put in place institutional and policy reform initiatives in the form of better governance systems, performance monitoring and improved financial management.

### National/State policy directives on reforms in water sector

#### *National Water Policy 2002*

India's National Water Policy 2002 has clearly identified the need for improvements in the management of water sector in the country and has identified the need for reorientation of the current institutional structure of the sector in a manner which promotes a multi sectoral, multidisciplinary and a participatory approach while giving special attention to the management/ O&M of water resource schemes (Box 1).

**Box 1**

With a view to give effect to the planning, development and management of the water resources on a hydrological unit basis, along with a multi sectoral, multi disciplinary and participatory approach as well as integrating quality, quantity and environmental aspects, the existing institutions of various levels under the water resources sector will have to be appropriately reoriented / reorganized and even created wherever necessary. The institutional arrangements should be such that maintenance of water resources is given importance equal or even more than that of new construction.

**Source:** National Water Policy, Ministry of Water Resources, Government of India

### *City Challenge Fund*

The Ministry of Urban Development, Government of India is encouraging citywide reforms and restructuring so as to ensure that cities are managed efficiently and become creditworthy (to attract private finance) which will enable them to prepare long term plans for infrastructure investments and implement poverty alleviation programmes. For the implementation of these reforms the Ministry of Urban Development has proposed to set up a performance based City Challenge Fund for catalyzing city level economic reform programmes. Access to the fund would be on a competitive basis.

### *Urban Reform Incentive Fund*

The Urban Reform Incentive Fund (URIF) has been created with a corpus of Rs 500 crores per annum as Additional Central Assistance for reform linked incentive to State Government. URIF is a state level incentivization programme. It seeks to incentivize State Governments to follow a certain reform programme decided by the Government of India. The incentive under URIF is provided as 100 per cent Grant to the States and Union Territories entering into a Memorandum of Agreement with the Central Government addressing the first phase reform. The first phase reforms are proposed for a number of areas inclusive of the following:

- Introduction of computerized process of registration.
- Levy of reasonable user charges, with full cost of O&M being collected by the end of the 10th plan period.
- Introduction of a double entry system of accounting.

### *MoUD Initiatives*

MoUD also proposes certain regulatory frameworks, which should be brought into effect in the water supply and sanitation sector. It also proposes to draw up guidelines for Public-Private Partnership to encourage PPP in infrastructure development (Box 2).

**Box 2**

**Regulatory Framework**

The participation of the private sector in financing and the delivery of infrastructure at the municipal level, especially in the water and sanitation sector, requires a regulatory framework to protect consumers, apply environmental standards and support the delivery to the poor. As there are a variety of models of regulation from centralized to decentralized systems, guidelines will be developed at the National level to ensure consistency across the country. Appropriate training programmes and capacity support to regulators will also be developed in partnership with the private sector and urban research institutions.

**Public-Private Participation Guidelines**

Central Government will develop guidelines for involvement of the private sector in infrastructure, which will ensure competitive biding process in a transparent manner. These guidelines will not only protect the consumers but also ensure integrity of the process. This would support municipalities in designing the PPP process on the lines of the BOT Centre in Philippines or the PPP in the Ministry of Finance in South Africa.

**Source:** Urban Reforms, Ministry of Urban Development, Govt of India

### *Jawaharlal Nehru National Urban Renewal Mission*

The need of the hour in most cities is to introduce and sustain reforms, and improve service delivery efficiencies with a focus on minimizing costs, maximizing revenue, and allocating resources in the most optimal manner, all of which are possible in the existing institutional framework. National Urban Renewal Mission, about to be launched by the government, will be completely "reform driven" with eligible cities having to belong to states that have displayed reforms in terms of repeal of Urban Land (Ceiling) Regulation Act, reform of rent control acts, rationalization of stamp duties to not more than 5% over the next five years, introduction of independent regulators for urban services, levy of reasonable user charges for basic urban services, constitution of Citizen Advisory Groups to guide urban reforms' processes, and e-governance, among others.

The funds allocated under this mission come from a combination of Central Government, State Government and also as loans from Financial Institutions. The release of Central assistance would be linked with implementation reforms. The Mission includes a list of mandatory and optional reforms of which States and Urban Local Bodies (ULBs) are required to implement all mandatory reforms. In addition, States & ULBs are required to implement any five optional reforms in the first year.

A summary of the various national programmes and policies related to urban water supply in India over the years is given in Table 1 below.

**Table 1** Various policy instruments/programmes used in the urban water supply sector in India

| Year | Policy/Act/Programme | Highlights |
|---|---|---|
| 1974 | Environmental Improvement of Urban Slums (EIUS) Scheme | • The scheme is applicable to notified slums in all urban areas.<br>• Aims at provision of basic amenities like water supply and sanitation.<br>• The EIUS scheme was made as an integral part of the Minimum Needs Programme in 1974. |
| 1979 | Integrated Development of Small and Medium Towns (IDSMT) | • The scheme was initiated with a view to augmenting civic services.<br>• Strengthening municipalities through promotion of resource generating schemes.<br>• Reducing migration from rural areas to larger cities by providing sufficient infrastructure facilities, including water supply. |
| 1986 | Centrally sponsored Rural Sanitation Programme (CRSP) | • Provide technical and financial assistance to states to implement rural sanitation programmes under the Minimum needs programme. |
| 1986, 1990/91 | Urban Basic Services Scheme (UBSS) (1986) / Urban Basic Services for the Poor Programme (UBSP) (1990/91) | • The primary objective was improving the standard of living of urban low-income households, particularly women and children through the provision of sanitation and social services in slum areas.<br>• In 1990/91, the scheme was integrated with the EIUS and came to be known as the Urban Basic Services for the Poor (UBSP) programme. |

| | | |
|---|---|---|
| 1991 | Rajiv Gandhi National Drinking Water Mission (RGNDWM) | • The Accelerated Rural Water Supply Programme (ARWSP) under the (RGNDWM) assists the States and Union Territories (UTs) to accelerate the pace of coverage of drinking water supply. |
| 1992 | 73rd and 74th Constitution (Amendment) Acts | • A three-tier system of local governance, through Panchayati Raj Institutions (PRIs) in rural areas and through Urban Local Bodies (ULBs) in urban areas was established.<br>• State legislatures were empowered to entrust local bodies with necessary power and authority to enable them to function as institutions of local self-government.<br>• State Finance Commissions were to be set up to provide for sharing of revenues between State and local bodies.<br>• The urban and rural local bodies are now responsible for Water supply and sanitation. |
| 1993/94 | The Accelerated Urban Water Supply Programme (AUWSP) | • The Programme was initiated by the MoUDPA to provide safe and adequate water supply facilities to the entire population of the towns having population less than 20,000 as per 1991 Census. 50% of the finance for the urban water schemes is provided by the Union Government and the rest by the State Government. |
| 1996 | National Slum Development Programme (NSDP) | • Additional Central Assistance is being released to States/ Union Territories for the development of urban slums.<br>• Objectives of the programme include provision of adequate and satisfactory water supply, sanitation, shelter upgradation, garbage, and solid waste management in slums.<br>• Focus areas of the NSDP include development of community infrastructure, empowerment of urban poor women and involvement of NGOs and other private institutions in slum development. |
| 2002 | Urban Reforms Incentive Fund | • Rs 500 crore to provide reform linked assistance to States on:<br>• Revision of municipal laws in line with model legislation.<br>• Levy of realistic user charges and resource mobilisation by urban local bodies.<br>• Initiation of public private partnership in the provision of civic services. |
| 2002 | City Challenge Fund | • Support to mega cities for transitional cost.<br>• Partial cost of developing an economic reform programme and financially viable projects undertaken by the ULBs. |
| 2002 | National Water Policy | • Drinking water should be priority in planning and operation of systems.<br>• Maintenance of existing water resources schemes would be paid special attention under these institutional arrangements. |

| | | |
|---|---|---|
| 2005 | National Urban Renewal Mission | • Participatory approach should be adopted and water user associations and local bodies should be involved in operation, and maintenance to lead to eventual transfer of management to the local bodies/user groups.<br>• Private Sector Participation should be encouraged in planning, development and management to introduce corporate management and improve service efficiency.<br>• A standardised national information system with a network of data banks and data bases, integrating and strengthening the existing Central and State level agencies should be established.<br>• Exploitation of ground water resources should be so regulated as not to exceed the recharging possibilities as also to ensure social equity.<br>• The thrust of this mission is on urban infrastructure and basic services for the poor. This mission plans to cover only 63 cities including 7 mega cities, 28 million plus cities, and 28 other cities over a five year period. The mission proposes an agreement between the states, urban local bodies and the central government to undertake reforms before delineation of funds from NURM to the ULBs. |

## State Government directives

### *MP State Water Policy*

The Madhya Pradesh state water policy also advocates institutional reforms including better coordination mechanisms and inclusion of demand side perspective in water management along with developing a reliable information system for better management and decision-making.

**Box 3**

Present information and data network including data of processing capabilities should be improved to make it broader, modern and effective. Emphasis should be given for greater use of Remote Sensing technique. It should be made mandatory for users and regulatory departments to maintain all necessary data for compilation of storage of surface and ground water…..

…..The water resources planning structure which is at present based on water availability should be correlated with demand base of water distribution and necessary institutional reforms be taken.

**Source:** State Water Policy, Madhya Pradesh, 2003

### 10th Five Year Plan (Draft)

The State Government has published its own Draft 10th Five-Year Plan 2002-2007 in May 2002. "The Plan recognizes the importance of people in the process of development. It further lays emphasis on "decentralization, greater accountability, and increasing space for direct community action".

**MP Municipal Corporation Act 1956 (With amendments)**

The Madhya Pradesh Municipal Corporation Act came into existence in 1956. Since then, all Municipal Corporations in the State are governed by this Act. The Act vests the powers for management and maintenance of all water works and the construction and maintenance of new works to the Municipal Corporations across the state. Further, it also directs the Municipal Corporation to find means for providing a sufficient supply of suitable water for public and private purposes.

It further defines the composition of the Municipal Corporation. The State has the provision to nominate persons having special knowledge and experience in the municipal affairs to be a part of the Municipal Corporation. Also, according to the act's mandate, a Mayor-in-council has to be brought in place in the city, which leads the pathway for public participation. Wards Committees/ Zonal Committees also need to be constituted by, as a step towards a decentralized approach.

In lieu of the above policy directives it may be necessary for the Municipal Corporations to undertake reforms aimed at improving the efficiencies and demonstrate that its operations and sustainable even for attracting funding from the government and also the institutional sector/external donors.

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