WATER AUDIT: A CASE STUDY OF WATER SUPPLY SCHEME OF SHRIVARDHAN.

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ABSTRACT- A water audit determines the amount of water lost from a water supply system and the cost of this loss to the utility. It will quantify Unaccounted for Water (UFW) and Non-Revenue Water (NRW). Water audits balance the amount produced with the amount billed and account for the remaining water (loss). Comprehensive audits can give the utility a detailed profile of the water supply system and water users, allowing easier management of resources and improved reliability. It is an important step towards water conservation and, if linked with a leak detection plan, can save the utility a significant amount of money and time.

Keywords: Unaccounted for Water (UFW); Non-Revenue Water (NRW)

I. INTRODUCTION

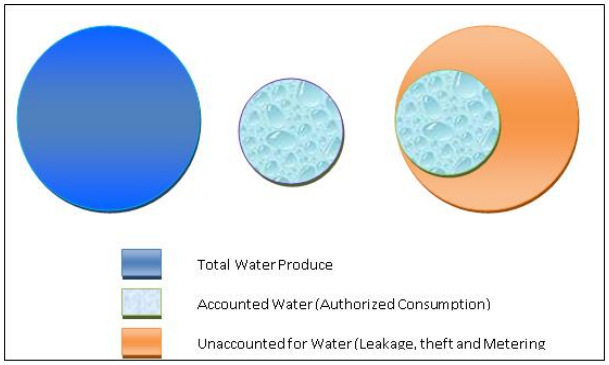
Water audit refers to the conducting of periodic exercises to determine water supplied into the distribution system as well as water lost and/or used within the distribution system, the water balance chart is the tool used to enhance a meaningful water audit report.

Developing a water balance is of paramount importance for the following reasons.

1. It serves as a framework for assessing a utility's water loss situation
2. Calculating the water balance
   a. Reveals availability/reliability of data and level of understanding
   b. Creates awareness of problems/issues
   c. Gives direction of improvements
3. It also serves as a tool for communication and benchmarking
4. Above all it provides significant guidance required for purposes of prioritizing attention and investments of limited resources.

The following benefits accrue from the reduction of NRW;

1. Cleaner database and more revenues
2. More water available for consumption
3. Cost reduction – less chemicals and electricity – optimized production
4. Deferred need for investments to increase production capacity
5. Reliable demand projections
6. Optimized operation of the distribution system.



II. COMPONENTS OF WATER AUDIT

- Head Works – for import of raw water
- Raw Water Gravity Main – for raw water consumption and losses
- Raw Water Sump & Pump House - for raw water consumption and losses
- Storage Reservoir – Distribution input, water supplied to DMA and treated exported water
- Distribution system – Pure water consumption, losses over distribution all over town
- Analysis of flow measurement with respect to standard water balance sheet
- Hydraulic modelling and Analysis for existing distribution system
- Proposing rehabilitation program

III. CASE STUDY OF WATER SUPPLY SCHEME OF SHRIVARDHAN

The Government of Maharashtra has undertaken "Sujal-Nirmal Abhiyan" project under which government insisted various urban local bodies to participate and such ULB improvement program has been taken up to increase serviceability of the system. Shrivardhan Municipal Council, also participated and intended to do various works in the field of water supply such as Carrying out Consumer Survey, Water Audit, Energy Audit, Providing and Installing Flow Meter, GIS Mapping, Hydraulic Modelling and Computerized Water Billing and Collection System.

The earlier studies carried for water supply improvements are reviewed and basic information is utilized for analysing existing water supply system for SMC area.

The population of Shrivardhan as per 2011 census is 15118. Population is marginally decreased than 2001 due to lot of people migrating to urban areas for work as Shrivardhan have very limited resources for earning.

Floating population is nearly 2000 persons per day in peak period and 800 persons per day during non-peak season. The average residing population is considered as 50% of total floating population and other 50% are day travellers.

Hence Total Present Population (2011) for SMS is tabulated below-

Sr. No.	**Particulars**	**Peak Day**	**Non Peak Day**
1	Present Resident Population	15118	15118
2	Residing Floating Population	1000	400
3	Non Residing Floating Population	1000	400
	Total Population	17118	16918

As per CPHEEO norms, following LPCD rates are considered for above categories of population in SMC area. The total water demand is also depicted in following table –

Sr. No.	**Particulars**	**LPCD Rate**	**Peak Day**	**Non-Peak Day**
1	Present Resident Population	70	1058260	1058260
2	Residing Floating Population	70	70000	40000
3	Non Residing Floating Population	15	15000	6000
	Total Demand		**1143260**	**1104260**
	Add 10% for other demands		114326	110426
	Total Demand		1257586	1214686
	Add 15% Losses		221927	214356
	Gross Demand		**1479513**	**1429042**
	Gross Demand in MLD		1.48	1.43

Total quantity of water supplied to Arathi and Metkarni area outside SMC boundary is given below –

Sr. No.	**Particulars**	**Supply Hours**	**Quantity of water supplied in LPD**
1	Domestic Consumer at Arathi	4.0	225000
	Domestic Consumer at Metkarni	18.0	165000
2	ST Workshop and Other Non Domestic Users	18.0	37000
	Total Demand	**22.0**	**427000**
	Gross Demand in MLD		0.43

Total demand of present area served by SMC is 1.91 MLD

From the water charges bills paid to Irrigation Department, it is observed that SMC is consuming 3.6 MLD of water including demand for Arathi.

Considering the consumption of 135 LPCD after the sewerage scheme is implemented in the town, the total present gross water demand will be as follows –

Sr. No.	**Particulars**	**LPCD Rate**	**Peak Day**	**Non Peak Day**
1	Present Resident Population	135	2040930	2040930
2	Residing Floating Population	135	135000	54000

3	Non Residing Floating Population	15	15000	6000
	Total Demand		**2190930**	**2100930**
	Add 10% for other demands		219093	210093
	Total Demand		2410023	2311023
	Add 15% Losses		361503	346653
	Gross Demand		**2771526**	**2657676**
	Gross Demand in MLD		2.77	2.66

Considering the projected population of 19063 for year 2041 and proportionate increase in floating population, gross water demand for projected year 2041 will be 3.53 MLD.

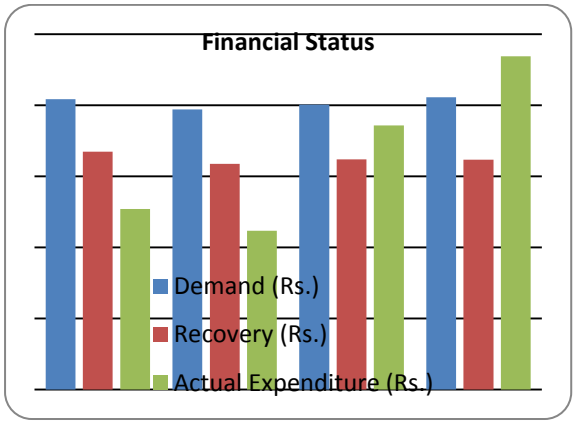
It is suggested that SMC should immediately approach to the Water Resource Department (WRD) i.e. Irrigation Department and apply for sanctioning the additional quota of 2.17 MLD from Ranvali dam.

AS the SMC is presently drawing average 3.2 MLD of water, hence it is presumed that Ranvali Dam has the capacity to serve SMC's additional demand in future as well.

WATER BUDGET

Bill Demand/ Recovery/ Expenditure

Year	**Demand (Rs.)**	**Recovery (Rs.)**	**Actual Expenditure (Rs.)**	**Recovery (%)**
2007-08	20,43,245/-	16,72,311/-	12,69,912/-	81.85 %
2008-09	19,70,140/-	15,87,009/-	11,17,002/-	80.55 %
2009-10	20,03,263/-	16,18,811/-	18,58,656/-	80.80 %
2010-11	20,54,841/-	16,16,744/-	23,44,174/-	78.68 %



IV. WATER AUDIT

Water audit of existing system is carried out from Source to tap in SMC area. Water & Energy Audit is carried out in three stages –

1. Pre-monsoon
2. Monsoon
3. Post Monsoon

The total area is divided in to three water Districts / District Metering Areas (DMA)

Sr. No.	**DMA**	**Total Consumers**		
		Residential	**Commercial**	**Total**
1	Shivaji chowk, Mahaveer Marg to Danda Area	756	9	765
2	Shivaji chowk, Mahaveer Marg to Danda Area	761	9	770
3	Shrivardhan Bus Depot to Shivaji Chowk and adjoining villages.	362	10	372
	Total	1879	28	1907

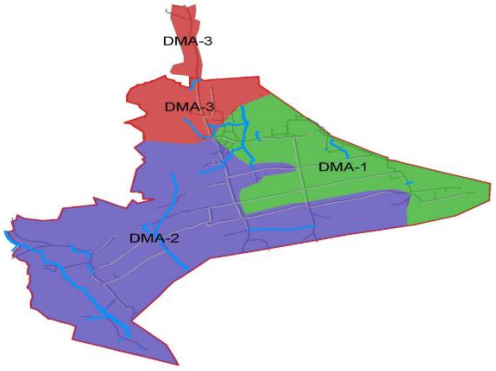
Table shows number of properties vis-a-vis number of consumers in SMC area.

Sr. No.	**Category**	**No of Properties**	**No. of Consumers**	**Total Family Covered by SMC Water Supply**
1	Residential	3558	1677 + 74 SP	2500 +(74X10) = 3240
2	Commercial & Other	409	28	56
	Total	3967	1705+ 74SP	3296

Hence percentage coverage of population under SMC water supply is about 83%.

Formation of District Metering Area (DMA)

- DMA-1: Shivaji Chowk to Mahaveer Marg, Moghal Mohall, Prabhu Aali, Rafi Kidwai Marg, Danada etc.
- DMA-2: Shivaji Chowk to Tilak Road, Dhond Galli, Peshave Aali, Jeevana and Kond area etc.
- DMA-3: Shrivardhan ST Stand to Shivaji Chowk, Arathi, Metkarni etc.
- Sub DMA – 2 100% Sub DMA in DMA-1 &2



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Observations on the Existing Water Supply System of SMC:

1) After commissioning the first water supply scheme of Shriwardhan town in the year 1987, the maintenance of the water supply components are overlooked. Thus the supply of the town is not steady and cause limited supply efficiency.

4.

2) Water supply components such as pipes pump house and pumping machineries etc. require immediate maintenance. Since there is no preventive maintenance and schedule of the water supply components, system components are not steady and causing frequent failure.

3) Present domestic population for year 2011 is approximately 15118. The floating population for peak period is 2000 and non-peak period is 800.

4) Since there is no sewerage system in existence, LPCD rate is considered as 70 LPCD based on CPHEEO guidelines.

5) Present gross demand of SMC area considering other demands and 15% losses in transmission & distribution network is worked out to be 1.48 MLD

6) SMC is also supplying water to Arathi, Metkarni and other small areas adjoining to SMC boundary including ST Depot etc. and this demand worked out to be 0.43 MLD.

7) Total gross water demand for present year worked out to be 1.91 MLD

8) Considering the losses in the distribution network from comprehensive water audit program i.e. 46%, total water demand from source is worked out to be 3.53 MLD.

9) The sanction quota of raw water at Ranvali Dam for SMC is 1.36 MLD and SMC should apply immediately to Irrigation department to increase the quota of raw water from Ranvali Dam for future provisions

10) Presently SMC fetching 3.20 MLD of Raw water.

11) Irrigation Department is charging 3.6 MLD of consumption to SMC on flat basis with penalized rates for additional usage over 1.36 MLD

- Rate of Raw Water – Rs. 1.50 / 10 KL
- Penalized Rate – Rs. 3.00 / 10KL
- Actual average Consumption is about 2.9 MLD
- Additional Amount Annually paid by SMC due to additional usage and the penalty – Rs. 90,000/-

12) Arathi gram panchayat has already started laying separate system for water supply and once commissioned, there quota will be deducted from SMC drawl.

13) In future when the sewerage system will be planned for SMC, water demand will increase drastically considering 135 LPCD rate as per CPHEEO guidelines. SMC should approach WRD and obtained additional quota from Ranvali dam.

14) After the site visit and subsequent discussion with SMC staff, it is observed that distribution network is serving the town for a long period. Most of distribution pipeline are of AC/PVC/GI material which are leaking. The connections to consumer are of GI fittings which are corroded and leads to further leakages. This could be the major sources of NRW.

15) SMC did not have water treatment facility to treat raw water from Ranvali Dam and hence raw water is supplied to consumer of SMC with chlorination at Arathi S&P House. Water supply through Bypass arrangement is without chlorination.

- SMC is now in process of inviting Tender for unconventional WTP as per the sanctioned scheme of MJP under Reform Works.
- The location of new WTP is identified at higher elevation near source i.e. LHS of Ranvali dam and upstream of proposed intake well.
- Water collected in proposed Intake well will be pumped to inlet of WTP and thereafter water will reach existing Arathi GSR by gravity bypassing exiting S&P house at Arathi.

16) Water tariff is based on fixed flat rate basis for residential and commercial consumers

17) Water is supplied to consumer without metering and hence control usage is not envisaged. Hence it is recommended that SMC should impose consumer metering system and tariff will be charged on volumetric basis with telescopic rates to bring control over wastage of water.

18) Revenue collection from consumer for water supply bills is average 81 % of demand.

19) Average 19 % deficit in revenue considering revenue collected and expenditure on water supply works.

- SMC should expand the peripheral areas of SMC boundary so that residents in far end and resident residing at higher elevation in Jeevana and Dhond Galli area shall be able to take connection from Municipal Council. This will help to increase the coverage up to 95 % and will aid in generating additional revenue.
- Stand post shall be discarded and group connections (5 to 6 consumer in one group) will be encouraged by offering lower tariff rate.

20) Considering newly developed areas additional storage reservoirs could be required for town.

- As per the present demand of 1.26 MLD, storage required as per CPHEEO norms is 0.42 MLD.
- Present storages in SMC area are 0.68 MLD
- If the demand increases due to implementation of sewerage scheme in near future, the total storage requirement will 0.80 MLD and hence additional storages will be required at suitable locations based on outcome of hydraulic analysis.

V. WATER BALANCE DIAGRAM

Complete Water Balance Sheet for Water Audit of SMC is presented below-

<table>
<tr><td rowspan="4">System Input Volume

MLD 2929.05 Cum/ Day</td><td rowspan="4">Authorized Consumption (Billed Authorized Consumption + Unbilled Authorized Consumption) MLD 1572.18 Cum/ Day (54%)</td><td rowspan="3">Billed Authorized Consumption MLD 1327.714 Cum/ Day (45%)</td><td>Billed Metered Consumption (Including water exported) Nil</td><td rowspan="3">Revenue Water (Total billed quantity) MLD 1327.714 Cum/Day (45%)</td></tr>
<tr><td>Billed Un-metered Consumption 1327.714 Cum/Day (45%)</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption Nil</td><td rowspan="2">Non-Revenue Water (System Input Volume - Total Billed Quantity) 1601.336 Cum/Day (55%)</td></tr>
<tr><td>Water Losses (System Input Volume – Authorized Consumption)

1356.87 Cum/ Day (46%))</td><td>Apparent Losses MLD 183.773 Cum/ Day (6%)</td><td>Unbilled Un-metered Consumption 244.466 Cum/Day (8%)</td></tr>
<tr><td rowspan="4">Real Losses (Water losses – Apparent losses) MLD 1173.097 Cum/ Day (40%))</td><td>Unbilled Un-metered Consumption 244.466 Cum/Day (8%)</td></tr>
<tr><td>Un-authorized Consumption 183.773 Cum/Day (6%)</td></tr>
<tr><td>Metering Inaccuracies Nil</td></tr>
<tr><td>Raw Water Transmission Losses 240.655 Cum/Day (8%)</td></tr>
<tr><td>WTP Losses Nil</td></tr>
<tr><td>Raw Water Distribution Losses 1116.215 Cum/Day (38%)</td></tr>
</table>

VI. SYSTEM ANALYSIS

Identify recoverable leakage in pipe line and valves.

Sr. No.	Component	Quantity
1	Total losses observed in the Gravity feeder mains and Distribution Network pipeline, specials and valves are about 40%	1173.097 Cum/Day
2	Daily Recoverable Leakages in Pipeline and Valve 20%	586.55 Cum/Day

Calculate the value of recoverable leakage.

Sr. No.	Component	Quantity
1	Annual Recoverable Leakages in Pipeline and Valve @ 20%	241090 KLD/Annum
2	Cost of Water loss @ Rs. 3.00 / 10 KLD (Penalized rate is considered as this is additional water exceeding approved quota)	Rs. 72327/- per Annum

Calculate the cost of recovering leakage:-

Leakages observed on the pipeline to be rectified immediately by department to avoid water loss. Replacing of leaky pipelines and valves are necessary but proposed in long term investment plan as the associated cost is more when compared with revenue loss by recoverable leakage.

The recoverable leakages should be given importance for water conservation because these losses reduce the storage capacity of Dam which causes water shortage during summer season.

Calculate the cost of Leak detection:-

Since the cost associated with recoverable water loss is less, leak detection using state-of-art instruments is not economically viable.

VII. IMPROVEMENT TO EXISTING WATER SUPPLY SYSTEM

As per the observations and recommendation from Comprehensive Water and Energy Audit program, following works are envisaged for improving service levels to the consumers of SMC.

The improvement works are sliced in to two phases –

1. Immediate Improvements
2. Long Term Improvements

Following table indicates the works to be carried out in two phases –

Sr. No.	System Components	Proposed Rehabilitation by WCS	
		Immediate Improvements	Long Term Improvements
1	Head Works	Arrangement for submerged inlet by fixing 90 deg. Bend and fix jali /mesh at inlet opening to avoid entry of floating matter in to the pipe line	Construction of new Intake Channel and Intake Well
2	Raw Water Gravity Main from Intake to Arathi S&P House	Observe the pipeline regularly in Khajan Land and remove the leakages immediately as this portion is more prone to leakage due to corrosion of pipe in this section.	Proposed to Replace old Cast Iron pipe with 250mm dia DI, K-7 pipe at the leaky and damaged pipe portion i.e. 3.5 Kms out of total 4.5 Kms pipe length
3	Arathi Sump & Pump House	Grout the cracks, openings in Sump Wall to avoid leakage / seepage.	Internal plaster for sump to avoid any seepage or leakages. Minor repairs and painting works to Pump House
4	Water Treatment	Proposed to construct Horizontal Filters on the periphery of sump 1.5 m wide for removal of turbidity / suspended solids etc.	MJP has given approval to construct new WTP in reform works and SMC will be constructing new WTP (unconventional) near source at higher elevation so that water after treatment will reach to Arathi GSR by gravity. This will eliminate the existing S&P house and hence SMC to take call whether to execute the work proposed by WCS or not.
5	Raw water	Nil	Nil

	rising main		
6	Pumps and Motors and other Electrical arrangements at Arathi, Jeevana & Dhond Galli Sump	Maintain the regular inflow to sump and observed the water levels to avoid dry run of pumps	Modification Suggested as per outcome of Energy Audit
8	Distribution Network	Distribution hours in Danda area to be increased by one hour with additional pumping in to Arathi GSR	Proposed to replace AC and GI pipes (60mm to 200mm dia) with HDPE pipelines of equivalent diameters.
9	Bulk Flow Meters	Nil	Proposed to install Bulk Flow Meters in Transmission & Distribution network for periodic water audit
10	Consumer Meters and HSC	Discard free stand post and provide group connections to the consumers BPL at Low tariff instead of free to reduce NRW	Proposed to install meters to all consumers and discard free public stand posts and charge consumer on Volumetric basis with telescopic tariff.

VIII. ANALYSIS OF AUDIT RESULT

- Identify recoverable losses
- Estimate the value of recoverable losses
- Estimate the cost of recovering losses and corrective measures
- Prepare the cost benefit Analysis
- Prepare Action Plan for implementation
- Monitor the result
- Update the audit
- Update the master plan

And it's a continues process.

IX. BENEFIT OF WATER AUDIT

- Reduced water losses
- Financial Improvement
- Increased knowledge of distribution system
- More efficient use of existing supply
- Safe guarding public health to safety
- Improved public relation
- Reduced legal liability
- Provides the yard stick for performance of O & M team

REFRENCES:

1) AWWA-American Water works Association Manual.
2) Detail Project Report on Water Audit of Ahmadpur Municipal Corporation, Management under Sujal Nirmal Abhiyan, State Government of Maharashtra.
3) Detail Project Report on Water Audit of Shreevardhan Municipal Corporation, Management under Sujal Nirmal Abhiyan, State Government of Maharashtra.
4) http://mjp.mah.nic.in
5) IWA- International Water works Association Manual.
6) IWWA- Indian Water works Association Manual.
7) Manual on Operation and Maintenance of Water Supply System Central Public Health and Environment Engineering Organisation (CPHEEO)
8) Manual on Water Supply and Treatment Central Public Health and Environment Engineering Organisation (CPHEEO) under Ministry of Environment & Forests Government of India
9) Ministry of Environment & Forests Government of India
10) Ministry 0f Urban Development Govt.of India www.moud.com
11) Sujal Nirmal Abhiyan GR of water supply -19, 2009 For Water Audit and Leak Detection, Govt. of Maharashtra.
12) Water supply Engineering by Santosh Garg.

