

Leak Detection of Water Supply System by Water Audit- A Case Study of Ahmedpur

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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)

1. INTRODUCTION

The Government of Maharashtra has undertaken "Sujal-Nirmal Abhiyan" project under which government insisted various urban local bodies to participate and improvement program has been taken up to increase serviceability of the system. Ahmedpur 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 analyzing existing water supply system for Ahmedpur Municipal Council area.

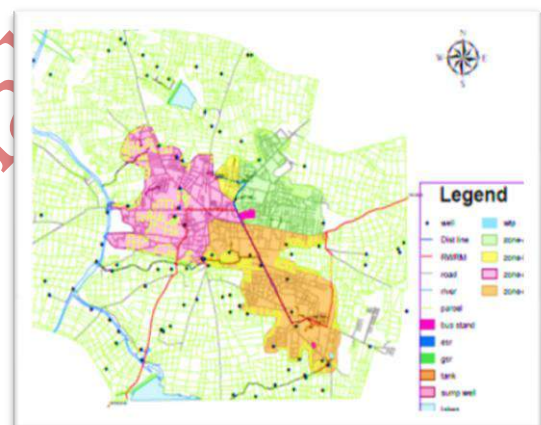


Fig 1: Base Map Showing Ahmedpur Water Supply System

The population of Ahmedpur as per 2011 census is 43468. Population of Ahmedpur is shown in Table 1 as per Consumer Survey carried out.

Table 1. Population as per Consumer Survey

Type of Property / Building	No. of properties	Population
House	9,831	48,730
Concert Hall	2	100
Government Office	37	247
Government Quarters	19	84
Hospital	34	186
Hostel	38	846
Industry	3	15
Medical Quarter	1	5
Mosque	12	12
Others	33	44
Private Office	26	158
Restaurant / Hotels	63	299
School/College	77	960

Shop	1061	4082
Temple	42	35
Theatre	2	13
Grand Total	11,281	55,816

As per CPHEEO norms, per capita water demand is considered for above categories of population in AMC area and the total water demand with 15% losses is depicted in Table 2.

Table 2. Water demand of Ahmedpur

Type of Property / Building	No. of Properties	Per Capita Water Demand	Total Water Demand
House	9,831	70	4013058.824
Concert Hall	2	15	1764.705882
Government Office	37	45	13076.47059
Government Quarters	19	70	6917.647059
Hospital	34	340	74400
Hostel	38	70	69670.58824
Industry	3	45	794.1176471
Medical Quarter	1	70	411.7647059
Mosque	12	70	988.2352941
Others	33	70	3623.529412
Private Office	26	45	8364.705882
Restaurant / Hotels	63	70	24623.52941
School/College	77	45	50823.52941
Shop	1061	45	216105.8824
Temple	42	70	2882.352941
Theatre	2	15	229.4117647
Grand Total	11,281		4,487,735

Total demand of present area served by AMC is 4.49MLD. Future water demand based on population projection & with 135 LPCD is as below-
Intermediate Design Year 2027- 11.25MLD
Ultimate Design Year 2042 - 15.32 MLD

AMC to ensure that proposed source allocation should be such that it suffices the need of ultimate project year. AMC should get the approval from Water Resource Department for the reservation of quota required for ultimate year.

2. CONSUMER SURVEY

Consultant has carried out detailed consumer survey in entire Ahmedpur Municipal Council (AMC) area and the outcome of study is summarized in Table 3.

Table 3. Coverage of Municipal Connections

Municipal Connection	Total
Yes	4859
No	6422
Grand Total	11281

The official no. of consumers on record of Municipal council are 3617. This means that 1242 nos. of consumer are having illegal connections.

Table 4. Details of the Consumer having no supply from Council

Source of Drinking water	Total
Bore Well	923
Dug Well	259
Open Well	659
(Blank)	4581
Grand Total	6422

Table 5. Methods of Drawing Water

Method Of Drawing Water	Total
Group Connection	122
Hand pump	75
Stand Post	109
Sump	4
Tap	4346
(Blank)	6625
Grand Total	11281

Table 6. Water Quality Study

Water Quality	Total
Good	9
Okay	4,789
Poor	61
(Blank)	6,422
Grand Total	11,281

3. WATER BUDGET

Bill Demand, Recovery and Expenditure of Ahmedpur Municipal Council is shown in Table 7 and Figure 2.

Table 7. Bill Demand, Recovery and Expenditure of Ahmedpur Municipal Council

Year	Demand (Rs.)	Recovery (Rs.)	Actual Expenditure (Rs.)	Recovery (%)
2007-08	62,07,198	20,23,833	69,94,338	33%
2008-09	69,21,917	25,32,663	83,89,014	37%
2009-10	75,05,775	30,02,500	56,79,991	40%
2010-11	80,53,987	40,62,476	94,33,527	50%

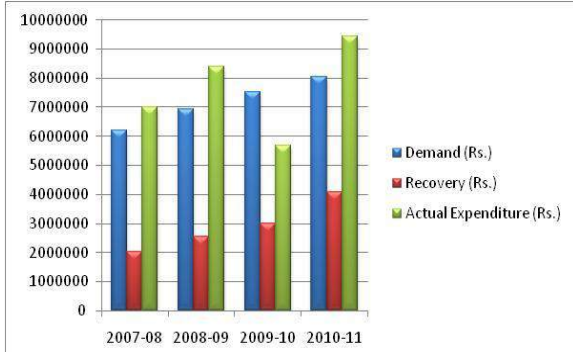


Fig 2: Bill Demand, Recovery and Expenditure of Ahmedpur Municipal Council

4. WATER AUDIT

Water audit of existing system is carried out from Source to tap in AMC area. Water Audit of Entire System is carried out as per the segment stated below:

1. Raw Water Rising Main
2. Water Treatment Plant
3. Pure Water Rising Main / Gravity Main
4. Storage Reservoirs
5. Distribution Network

Water Audit in Distribution Network is carried out in three supply zones as per the schedule of water supply which is about once in 7 days for almost all areas

5. WATER LOSS

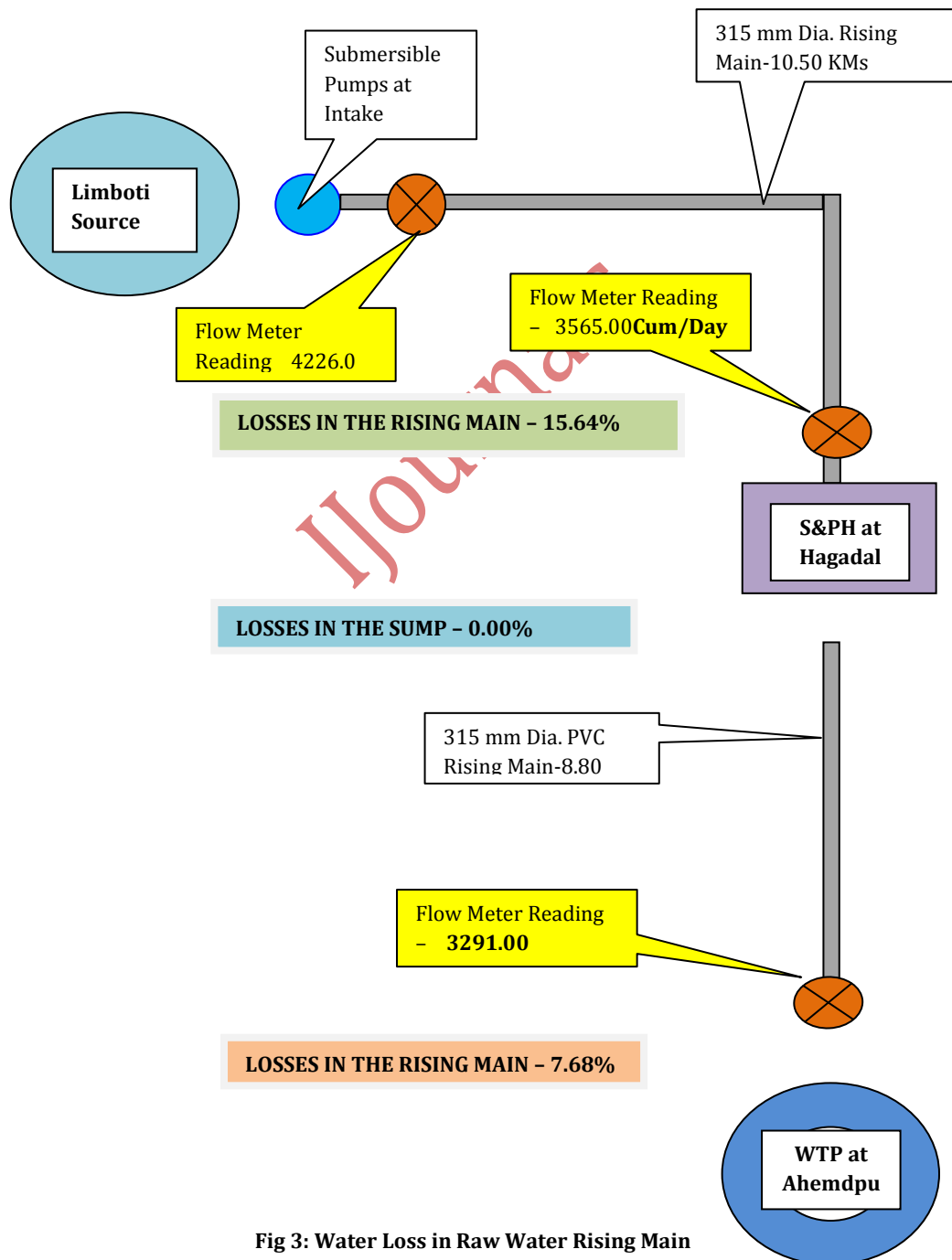


Fig 3: Water Loss in Raw Water Rising Main

5.1 Losses in WTP

Water losses in existing Water Treatment Plant are given below-

Water loss = Inflow from Hagdal IPS to WTP Inlet - Outflow from Clear water S&P House at WTP (Inlet of ESR and Sump)

Water loss = 3291.00 Cum/Day - 3148.00 Cum/Day

Water loss = 143.00 Cum/Day

Losses in the WTP units = 143.00 Cum/Day / 3291.00 Cum/Day = 4.30%

Losses in the WTP units = 4.30%

5.2 Losses Due To Overflow of Storages

Water losses in existing Storage Reservoir are given below-

Water loss = Inflow to ESR - Outflow to ESR

Water loss = 3148.00 Cum/Day - 3112.00 Cum/Day

Water loss = 36.00 Cum/Day

Losses in the All Storages = 36.00 Cum/Day / 3148.00 Cum/Day = 1.10%

Losses in the All Storages = 1.10%

These losses are occasional and can be controlled by proper instrumentation and management.

6. WATER AUDIT IN DISTRIBUTION NETWORK

Water Audit in Distribution Network is carried out for three supply zones from the existing storage reservoirs as per the supply schedule and shown in Table 8, 9, 10.

Table 8. Estimation of Losses in WTP ESR Zone

DATE	TIME	WTP ESR SUPPLY ZONE	DISTRI. TOTAL in Cum/Hr	EFM TOTAL	TOTAL LOSSES in%
25-Feb	12.15 TO 2.15	MAIN LINE CONN.	609.46	726	16.05%
		DESHMUKHWADA			
		PATIL GALLI			
		TELI GALLI			
		BRAMHIN GALLI			
26-Feb	10.25 TO 1.15	HALSE NAGAR	820.38	1669	24.88%
		DUSTAGIR			
		FULARI LINE			
		MAIN ROAD			
	7.40 TO 9.45	BAGWAN 1	433.38		
GADE GALLI					
27-Feb	8.57 TO 12.23	MARWADI	673.38	901	25.26%
		BHISTI			
		MAIN BRANCH			
		DHOR			
		PANCHSHIL NAGAR			
		BAGWAN 2			
28-Feb	6.30 TO 8.30	KHATIK	441.39	1791	25.52%
		MAIN LINE CONN.			
		MAIN LINE			
	12.15 TO 5.15	MIRKALE NAGAR(1)	703.92		
		MIRKALE NAGAR(2)			
	8.30 TO 10.50	PETROL PUMP LINE	188.60		
MASHJID AREA					
29-Feb	10.50 TO 12.50	BANK COLONY	674.33	1513	18.10%
	8.30 TO 10AM	BILAPATTE LINE	564.77		
	6.30 TO 8.30PM	TEMBHURNI LINE			
	8.30 TO 10.10	SAINIK COLONY			
1-Mar	6.30 TO 8.30	GANESH NAGAR	1313.89	1648	20.27%
	12.15 TO 2.15	KUMTHA COLONY			
	3.25 TO 4.40	REDDY COLONY			
	9.35 TO 10.45	GAIKWAD COLONY			
2-Mar	9.10 TO 11.10	SARASWATI COLONY	399.40	1176	29.16%
		HOUSING SOC.			
		VANKATESH NAGAR			
		SABRI LINE			
		MAIN LINE CONN.			
	7.20 TO 9.15	FULE NAGAR	433.69		
		NATH NAGAR			
		SHOPPING LINE			

		MAIN RD. -SHIVAJI CHOWK			
		MAIN LINE CONN.			

Table 9. Estimation of Losses in WTP ESR Zone

DATE	TIME	WTP ESR SUPPLY ZONE	DISTR. TOTAL in Cum/Hr	EFM TOTAL Cum/Hr	TOTAL LOSSES in%
25-Feb	7 TO 11	HANUMAN TEKDI	754.566	2246	26.35%
		HANUMAN TEKDI (END)			
		KEDAR LINE			
		UGILE			
		BANSODE			
	3.40 TO 5.10	RUKME NAGAR & REDDY COLONY	516.393		
		M.FULE SOC.			
	9.45 TO 12	TEACHER COLONY	383.237		
26-Feb	10.15 TO 11.58	NAGESH COLONY	498.299	687	27.47%
		GADEWAR			
	10.00 TO 11.45	MANDUMLE			
		DEVKATE			
27-Feb	11.30 TO 1.50	LECTURE COLONY	956.042	1238	22.78%
		GANIMISTRI			
	1.50 TO 3	MAIDABI			
		GHAYAL			
	9 TO 10.30	ADARSHNAGAR			
28-Feb	6.3 TO 9.25	BHAGYANAGAR	819.837	882	7.05%
	4.45 TO 6.38	SIDDARTHNGAR			
29-Feb	9.15 TO 11	LAMBTURE	890.424	1081	17.63%
		11 TO 1.15			
	1.15 TO 3.30	GORGHIL-1			
		VAKIL COLONY			
7.55 TO 9.14	OLD L.I.C				
	OLD CITY				
1-Mar	6.15 TO 8.15	GORGHIL-2	733.70	978	24.98%
	11.50 TO 2.35	KARADNAGAR			
	2.35 TO 3.35	JUDGE QTR LINE			
	6.25 TO 7.35	KARADNAGAR			
2-Mar	12.45 TO 3.30	NOOR COLONY	1017.22	1365	25.48%
	3.30 TO 5.10	WATHORE			
	9.30 TO 11.30	SHIVAJINAGAR			
3-Mar	6.50 TO 8.45	DIXISHIT	847.927	1124	24.56%
	10.15 TO 11.45	KARADNAGAR			
	12.35 TO 3.45	CHAMNAGAR			
		VITTHAL WADI			
	3.45 TO 5.30	VIDYANAGAR			

Table 10. Estimation of Losses in WTP ESR Zone

Date	Time	WTP ESR Supply Zone	NO. of Connections	Distri. Total in Cum/Hr	EFM Total Cum/Hr	Total Losses in%
25-Feb	3.00 HRS	MAIN ROAD	28	468.513	600	21.91%
		CHOR TAKI	20			
		JAGDAMBA MANDIR RD.	64			
		DARGAPURA	23			
		POLICE QUARTERS	2			
26-Feb	3.00 HRS	LINE GALLI	32	486.645	600	18.89%
		SOLAPURE	12			
		MAHADEV	83			
		WADARWADA	13			
27-Feb	4 HRS	BHARATNAGAR-1	80	540.65	600	9.89%
		BHARATNAGAR-2	85			
	4 HRS	MEHBUBNAGAR-1	62			
		MEHBUBNAGAR-2	60			

28-Feb	4 HRS	CHOUNDANAGAR	62	508.89	600	15.19%
		MAULANINAGAR-1	112			
	4 HRS	MAULANINAGAR-2	45			
		MONDA BHAG	11			
29-Feb	8 HRS	INDIRANAGAR	306	507.92	600	15.35%
		MAHASUL COLONY	24			
1-Mar	3 HRS	BOUDDHA NAGAR	15	442.24	600	26.29%
		MANKUDLE	37			
		ARAFAT COLONY	73			
2-Mar	2 HRS	BHIMNAGAR	65	421.299	601	29.90%

7. NINE TASK WATER AUDIT

Water audit is based on water balance of that water supply system. The water balance of Ahmedpur Municipal Corporation is shown in Table 11.

Table 11. Water Balance Diagram

A	B	C	D	E	
System Input Volume MLD 4226.00 Cum/Day	Authorized Consumption (Billed Authorized Consumption + Unbilled Authorized Consumption) MLD 1581.38 Cum/Day (37.42%)	Billed Authorized Consumption MLD 1466.38 Cum/Day (35%)	Billed Metered Consumption (Including water exported) Nil	Revenue Water (Total Billed Quantity) MLD 1466.38 Cum/Day (35%)	
			Billed Un-metered Consumption 1466.38 Cum/Day (35%)		
			Unbilled Authorized Consumption MLD 115.00 Cum/Day (3%)	Unbilled Metered Consumption Nil	Non-Revenue Water (System Input Volume - Total Billed Quantity) 2759.62 Cum/Day (65%)
				Unbilled Un-metered Consumption 115.00 Cum/Day (3%)	
		Apparent Losses MLD 876.62 Cum/Day (21%)	Un-authorized Consumption 876.62 Cum/Day (21%)		
			Metering Inaccuracies Nil		
		Real Losses (Water losses - Apparent losses) MLD 1768.00 Cum/Day (42%)	Raw Water Transmission Losses 935.00 Cum/Day (22%)		
			WTP Losses 143.00 Cum/Day (3%)		
			Storages Overflow Losses 32.00 Cum/Day (1%)		
			Raw Water Distribution Losses 658 Cum/Day (16%)		

The real losses are accounted to 42% and NRW components accounted to 65%.

8. OBSERVATIONS

1. Total quantity of water lifted daily is about 4.226 MLD

2. Present domestic population for year 2011 as per Consumer Survey is 48730. The floating population considering offices, schools, industries,

- shops etc is 7086. Hence the total population is 55816.
- Since there is no sewerage system in existence, LPCD rate is considered as 70 LPCD based on CPHEEO guidelines.
 - Present gross demand of AMC area considering other demands and 15% losses in transmission & distribution network is worked out to be 4.04 MLD
 - Considering the losses in the distribution network from comprehensive water audit program i.e. 54%, total water demand from source is worked out to be 7.48 MLD.
 - The sanction quota of raw water at Limboti Dam / Mannar Reservoir for AMC is approved by WRD.
 - Presently AMC fetching 4.226 MLD of Raw water.
 - Irrigation Department is charging raw water @ Rs. 1.70 per 10 Cum.
 - In future when the sewerage system will be planned for AMC, water demand will increase drastically considering 135 LPCD rate as per CPHEEO guidelines. The water demand considering 135 LPCD for year 2042 is worked out to be 15.32 MLD.
 - AMC should apply to Irrigation department to reserve the quota of raw water from said source for future provisions
 - During Water Audit Study, it is observed that
 - Air Valves on Raw Water Rising Mains are leaking continuously leading to major water loss in stretch from Source to WTP
 - Storages such as sump/ESR are overflows frequently and leads to losses
 - 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.
 - Consumers are fixing booster pumps on tap to draw more water in short span of time as water is being supplied once in seven days for limited period of 1.5 to 2.0 hrs.
 - Water is supplied to consumer without metering and hence control usage is not envisaged.
 - AMC is having common water treatment facility (4.0 MLD) to treat raw water from all sources.
 - Water tariff is based on fixed flat rate basis for residential and commercial consumers

- Revenue collection from consumer for water supply bills is average 50 % of demand.
- Average 50 % deficit in revenue considering revenue collected and expenditure on water supply works.
- Considering newly developed areas additional storage reservoirs could be required for town.

9. SERVICE LEVEL BENCHMARKING

Table 12. Benchmark

Benchmark	Target	Actual
Household Coverage For Water Supply Connection	100%	61%
Per Capita Water Supply	70 LPCD	71 LPCD
Extent of Metering of Water Connections	100%	0%
Extent of Non-revenue Water	20%	57%
Continuity of Water Supply	24 Hours	1.5 to 2.0 Hrs - Once in a week

Table 13. Benchmark

Benchmark	Target	Actual
Cost Recovery in Water Supply Services	100%	40%
Efficiency in Collection of Water Supply Related Charges	90%	50%
Efficiency in Redressal of Customer Complaints	80%	Need Attention
Quality of Water Supplied	100%	90%

10. IMPROVEMENT TO EXISTING WATER SUPPLY SYSTEM

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

The improvement works are sliced in to two phases –

- Immediate Improvements
- Long Term Improvements

Table 14 indicates the works to be carried out in two phases.

Table 14. Proposed Rehabilitation

Sr. No.	System Components	Proposed Rehabilitation by WCS	
		Immediate Improvements	Long Term Improvements
1	Head Works	Arrangement for required submergence of submersible pumps at Limboti Intake location	Construction of approach bridge and Rehabilitation of newly constructed Intake Well
2	Raw Water Rising Main from Intake to WTP	Replace all air valves on the pipeline with anti theft air valves with M.S. caging to avoid malfunctioning by en-route villagers	Replace old PVC pipe with required dia DI, K-9 pipe from Intake pumps to WTP about 19.30 kms
3	Storages at S&P house, WTP and Distribution System	Install ultra sonic level indicator at each sump and ESR at all locations in AMC area	Flow Control Valve and Float Control Valve should be installed at every storage location

4	Water Treatment	Proper arrangement for pre-chlorination and post chlorination at WTP	Additional WTP may be required in future for additional demand due to projected population
5	Distribution Network	Plug the old / shifted connections Compel consumers to fix ferrule on distribution main and discourage fixing of boosters on connections	Distribution network remodeling is carried out considering supply required quantity of water to each consumer with minimum 7.0m residual pressure at tap. Increase coverage of consumers in AMC area by providing expansion of distribution network
6	Bulk Flow Meters	Provision of 2 portable ultrasonic flow meters to carry out Water Audit of any section in the network	Proposed to install Bulk Flow Meters in Transmission & Distribution network for periodic water audit
7	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.

11. PROPOSED TARIFF STRUCTURE

Existing tariff is on flat rate basis for Domestic and Non Domestic Consumers. Domestic Consumers are charged at Rs. 806 per Month as fixed charges. It is proposed to fix consumer meters and apply

volumetric billing with following slabs of telescopic tariff to increase revenue and or reduce water consumption.

Present Water Demand for year 2011 is Rs. 4053987/- which can increase up to Rs. 6703500/- if proposed tariff plan is implemented.

Table 15. Proposed Tariff Structure

No. of Consumers	% Contribution	Consumption Slab	Avg. Monthly Consumption (Cum)	Tariff Proposed (Rs/Cum)	Expected Monthly Revenue
Residential Consumers					
1000	20	<10000	7500	5	60,000
2500	50	10000 to 15000	10225	7	193,750
750	15	15000 to 20000	2835	10	90,000
500	10	20000 to 25000	14130	12	87,500
250	5	>25000	4875	15	60,625
Commercial Consumers					
89	-	Up to 30000	2670	25	66,750
					558,625
				Annual Demand in Rs.	6,703,500

12. BLOCK COST ESTIMATES

Summary of Block Cost Estimate suggested from outcome of water audit and energy audit are tabulated below.

Table 16. Summary of Block Cost

Sr. No.	System Components	Block Cost(Rs.)
A	Civil Works	
1	Replacement of old air valves with 50mm dia. antitheft air valve with M/S. cage etc. complete.- 39 nos.	6,68,327
2	Providing Portable Ultrasonic Flow Meter for online water Audit etc. complete- 2 nos.	7,00,000
3	Providing and fixing Mercury Water Level Indicator at each storage location etc. complete - 5 nos.	89,100
4	Rehabilitation of Distribution Network for immediate improvements	1,97,14,127
5	Consumer Meters (ISO, Class -B, Multi jet type, 4859 Nos.)	1,82,92,111
6	Miscellaneous expenses for leakage on Valves, replacement of valves, Construction of Valve Chamber, Providing chlorination system at WTP (5MLD capacity) etc. complete	1,68,800
	Total of Sub work- A	3,96,32,472
	Say Rs.	3,96,32,500

13. 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.

14.ANALYSIS FOR NON-REVENUE WATER REDUCTION PROGRAM

Table 17.ANALYSIS FOR NRW REDUCTION PROGRAM

Sr. No.	System Component	% Loss as per WA Study (NRW)	Possible Saving in %	Quantity of Water lost (Cum/D ay)	Annual Amount of Loss of Water	Proposed Remedial Measures	Approximate Cost for Rehabilitation	Pay Back Period in Months
1	Raw Water Rising Main	21%	17%	935	1740503	Remove all leaky air valves and replace with new air valves with M.S. caging with locking arrangements to avoid damage of air valves for usage of illegal water by the users of enroutte villages	1368327	9
2	Water Treatment Plant	3%	0%	135	0	Since Council is already having arrangement for recycle of filter backwash water, additional saving is not envisaged	0	Not Applicable
3	Leakages & Overflows at Storages	1%	1%	32	73584	Install ultra sonic level indicator at each sump and ESR at all locations in AMC area	89100	15
4	Losses in Distribution Network	16%	6%	658	567402	Replace the old C.I., A.C. and G.I. pipes with DI (K-7) for more than 200mm dia pipelines and HDPE pipes for 80mm to 200mm dia. pipelines and ensure minimum 7m pressure at ferrule at any location in the network	0	0
5	Consumer Meters	LPCD - 98	LPCD-70		2700000	Fix Consumer Meters (ISO, Class -B, Multi jet type, 4150 Nos.) on every connection and apply telescopic tariff so that excess usage can	12645050	56

						be avoided or extra revenue can be generated		
6	Conversion of stand post in to individual or group connection	3%	3%	115	264443	Install ultra sonic level indicator at each sump and ESR at all locations in AMC area	1660615	75
7	Unauthorized Use / Illegal Connections	13%	13%	541	1244030	Install ultra sonic level indicator at each sump and ESR at all locations in AMC area	8062362	48
	TOTAL	57%	40%	2416	6589960		43539588	

For estimation of revenue water loss rate of water in considered as Rs. 6.30 / KL which is as per the present tariff plan.

15. 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.

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