Detailed Water Audit Report of Thermal Power Station

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ABSTRACT:

Water auditing is a method of quantifying water flows and quality in simple or complex systems, with a view to reducing water usage and often saving money on otherwise unnecessary water use. There is an increasing awareness around the globe of the centrality of water to our lives. This awareness crosses political and social boundaries. In many places people have difficult access to drinking water. Often it is polluted. Water auditing is a mechanism for conserving water, which will grow in significance in the future as demand for water increases. The aim of this research programme is to develop better information on water and sanitation performance and to ensure its use by the cities for extending services to all, strive for financial viability and improve reliability and quality of services. This research shall focus on the use of these performance indicators and benchmarks to facilitate consistent reporting, monitioring, planning and identifying water conservation opportunities including re-use and rainfall capture. This project is being implemented by SGS India Pvt Ltd to carry out a comprehensive water efficiency audit to identify current water usage patterns and to recommend related plumbing retro-fits and water saving initiatives, demonstrating the costs and savings including payback period

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INTRODUCTION

1.1 Water Scenario- Barh Super Thermal Power Station (BSTPS)

Barh Super Thermal Power Station draws water from Ganga river through a set of 6 numbers of pumping system (3x5510 m3/hr for stage-1 and 3x3750 m3/hr for stage-II) named as raw water pumping system. Out of the total six numbers of pumps two numbers ofhe pumps are for stage-I and rest of three are to deliver water for stage-II. Generally one pump for stage-II is in operation to fulfil the demand of raw water for stage-II, however one additional pump need to be operate on requirement. 5 numbers of the capacity 1100 m3/hr each of another pumping system named as “Barge Pumps” also installed to deliver the water in case of raw water pumps are in maintenance.[1]

Raw water pumps supplies the water to reservoir and the water further supplied to plant (pre-treatment section) with the help of another set of pumping system named as “Raw water make-up pumps (PT pumps). 5 numbers of pumps are installed in PT pump house which supplies water to plant for further use. [2]The total water consumption measured to the plant is 2870 m3/hr. The average power generation in stage-II during the measurement was 1020 MW. Shown below the table indicates water consumption (m3/hr) and specific water consumption of station**:**

Table No. 1:-Water Flow & specific Water Consumption Calculation

Specific Water consumption Calculation		
Particulars	**Unit**	**Values**
Total Power generation	MW	1020
Water flow	m^3/hr	2870
Sp. Water consumption	liter/kWh	2.814
Plant Load factor	%	77

Raw water from PT pumps discharge distributed to three different sections like clarifier section, potable water and DM clarifier section. The water flow distribution of stage-II of raw water is shown below table:

Table No. 2:- Raw Water Distribution

Raw Water Distribution		
Particulars	**Unit**	**Values**
Clarifier Water to CW Clarifier section	m^3/hr	2635
DM Clarifier	m^3/hr	210
Potable Water	m^3/hr	25

1.2 Observation and Analysis

The above figures indicates out of total raw water consumption in Thermal Plant, water flow to Clarifier is 92% (2575 m3/hr), while water to portable water is 1% (25 m3/hr) and water consumption in DM Clarifier section is 7% (210 m3/hr) of total raw water.

The specific water consumption (litre/kWh) is calculated as 2.814 Litre/kWh at average generations of 1020 MW with a PLF of 77%.

***Shown below a complete water diagram of station

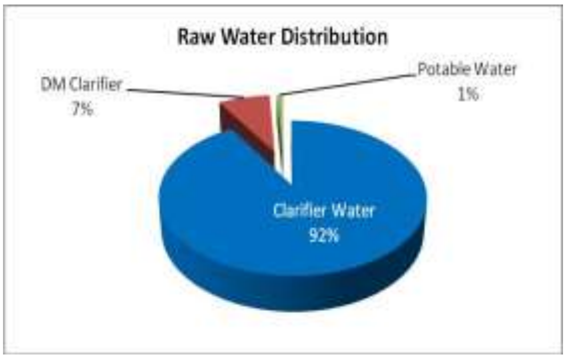

Figure 1: Raw Water Distribution in Different Sections

Water consumption and distribution of the station is shown below table followed by a diagram.

Table 3: Water Consumption & Distribution

Type of Water Supply	Unit	Values
Total Raw Water flow	m^3/hr	2870
Evaporation Losses	m^3/hr	1710
Plant Drinking water	m^3/hr	25
DM Water consumption	m^3/hr	210
Ash water make-up	m^3/hr	201
AC system Make-up	m^3/hr	56
Plant fire/service water	m^3/hr	636

Basis of Calculation[3]

Evaporation loss shown in the table has been calculated using the formula as shown below:

Evaporation Loss (m3/hr) = 0.00085 x 1.8 x water circulation rate (m3/hr) x [CT Inlet (oC) - CT outlet (oC)]

Note- The source of formula written above is hand book of Bureau of Energy Efficiency, book-III, Section 7.2 (cooling tower performance).[4]

The sample calculation of one shell is shown below:

CT# 4A:

Water Flow rate : 35149 m3/hr

CT inlet (oC) : 37.5 oC

CT outlet (oC) : 29.3 oC

Evaporation loss (m3/hr) = 0.00085 x 1.8 x 35148 x (37.5-29.3) = 441 m3/hr

Further evaporation losses in different cooling towers are shown below:

Evaporation Loss Calculation				
Cooling Tower ID	**Water flow (m^3/hr)**	**I/L Water Temp**	**O/L Water Temp**	**Evaporation loss (m^3/hr)**
Cooling Tower # 4A	35148	37.5	29.3	441
Cooling Tower # 4B	36583	37.2	29.1	453
Cooling Tower # 5A	32980	37.1	29.3	395
Cooling Tower # 5B	35729	37	29.2	421
Total Evaporation Loss				**1710**

Table No. 4:- Evaporation Losses and Calculation

Evaporation Loss Calculation

Note: The flow measurement at cooling towers was measured at 31st March 2018 and evaporation was calculated for the same date.

Two numbers of PT (Raw water make-up) pump was in operation during the flow measurement**.**

The above figures indicates out of total raw water entering (2720 m3/hr) in Thermal Plant, distributed to different places in plant water which are being consumed directly is evaporation losses in 5 numbers of 2 unit is 1710 m3/hr (63%).

Further 25 m3/hr (1%) is being consumed as plant drinking (potable) water, 210 m3/hr (8%) is being consumed in DM plant.

Out of total raw water, 201 m3/hr is being consumed as make-up water in Ash plant.[5]

It was observed that 636 m3/hr is being consumed as plant service water in stage-II, which is not being recovered.

Below table indicates the all type of water distribution values in the station.

Table No. 5:- Water Distribution/Usage Summary

Particulars	Unit	Stage-2
Raw Water	m^3/hr	2870
Service & Fire water	m^3/hr	636
Make-up water in ash system	m^3/hr	201
Drinking Water	m^3/hr	25
DM Water	m^3/hr	210
Circulating Water	m^3/hr	141330
Ash Water	m^3/hr	2721

Note: Drinking water, DM water is common for both the units of the plant.

Recirculation from PT pumps discharge header was observed during the measurement and quantity of 80 m3/hr water was measured. The recirculation leads to power and energy losses in pumping system. It should be stopped by correction of valve or installation of motorize valve. The power & saving calculation is shown below table :

Table 6: Optimization of Recirculation from PT Pump Header

Optimization of recirculation from PT Pump header		
Particulars	Unit	Values
Water Flow	m^3/hr	80
Net Head	m	24.75
Overall efficiency	%	59%
Power saving	kW	10
Operating hrs	hrs/day	24
Annual operating days	days/yr	300
Energy saving	kWh/yr	72852

2. Clarified Water

Raw water from PT pumps is further distributed to pre treatment section of the plant. One of them is clarified water section. Raw water from PT pumps comes to a reservoir through a clarifier and further distributed to cooling water sump as make-up water of main cooling towers. [6]

Few quantity of water from the discharge header of CW pump is being used as make-up water in ash plant and as service water in plant and same is called as Blow down water.

A total of 2485 m3/hr water flow is being supplied to clarifier tank. A quantity of 56 m3/hr is also being supplied from clarifier tank to AC system.Distribution of the clarified water from clarifier pump is shown below in table followed by pi-chart:

Table 7: Pre-Treatment Plant Water (Clarified Water) Distribution

Pre-treated water		
Particulars	Unit	Values
Total Water flow to CW forbay	m^3/hr	2575
Evaporation in cooling towers	m^3/hr	1710
CW blow Down	m^3/hr	837
HVAC Water	m^3/hr	56

2.1 Observation and analysis

Two clarified water & one AC system pumps were in operation during the measurement.

Out of total quantity of 2575 m3/hr from clarifier section, a quantity of 1710 m3/hr is being consumed in evaporation loss in cooling tower (i,e, make-up water for CT), 636 m3/hr is being consumed in as servicer water and ash system make-up water (201 m3/hr). 56 m3/hr water is being circulated to AC system and consumed.

It was observed and discussed with plant personal that the quantity of 56 m3/hr as HVAC system make-up is high and can be reduced up to 50% to save water.The saving calculation is shown below:

Table 8: Optimization of HVAC Make-up Water Flow

Optimization of HVAC make-up water (@50%)		
Particulars	Unit	Values
Present Scenario		
Measured water flow	m^3/hr	56
Operating hours	Hrs/day	24
Annual operating days	Days/yr	300
Estimated water quantity	m^3/day	1344
Estimated water quantity	m^3/yr	403200
Water cost considered	INR/m^3	4
Annual monetary cost	INR/yr	1612800
Proposed Scenario		
Water usage quantity (@ 50%)	m^3/hr	28
Estimated water quantity	m^3/day	672
Estimated water quantity	m^3/yr	201600
Annual monetary cost	INR/yr	806400
Savings Possibilities		
Water usage quantity	m^3/hr	28
	m^3/day	672
	m^3/yr	201600
Monetary cost	INR/yr	1411200
Investment required	INR	Nil
Simple payback period	months	Immediate

Recirculation from the discharge header of clarified water pump was observed and leads to power loss. It is suggested to install motorize valve to optimize the water recirculation to save power. The saving calculation is shown below:

Table 9: Optimization of Recirculation from Clarifier Pump Header

Optimization of recirculation of water from HVAC pump header

Optimization of recirculation of water from HVAC pump header		
Particulars	Unit	Values
Water Flow	m^3/hr	35
Net Head	M	86
Overall efficiency	%	53%
Power saving	kW	17.31
Operating hrs	hrs/day	24
Annual operating days	days/yr	300
Energy saving	kWh/year	124665

3. Circulating Water System

Cooling Water from cooling towers through CW pumps supplies water to condensers and to suction of ARCW pumps. The water returns to cooling tower through a common header from unit after removing the heat from condensers and auxiliaries. The water path is called circulating water.

There are 4 numbers of cooling towers for stage-II at BSTP. Water circulates to the units through 5 numbers of installed pumps from a common header which separates later to respective units.

4 numbers of pumps were in operation to circulate the water in both the units.

3.1 Observation & Analysis:

A total of 5 numbers of CW pumps are installed in stage-II for two units and are supplying water to all two unit by a common discharge line. The combine circulating water pumping power is 10917 kW.

Water flows to individual unit cooling towers were measured.

Total water flow to unit#4 is measured as 71732 m3/hr and 68710 m3/hr in unit#5.

Water flow to cooling tower# 4A & 4B is as measured as 35149 m3/hr and 36583 m3/hr respectively and water quantity in CTs# 5A & 5B is 32981 m3/hr and 35729 m3/hr respectively.

Total make-up water flow is being circulated from clarifier is calculated as 1710 m3/hr.

Evaporation loss is calculated in different CTs (CT # 4A, 4B, 5A, 5B) is calculated as 441 m3/hr, 453 m3/hr, 395 m3/hr, 421 m3/hr respectively.

Recirculation of a quantity of 885 m3/hr was observed from the discharge header and should be stopped to reduce power loss.

Table 10: Optimization of Recirculation from CW Header

Optimization of recirculation from CW header to chamber

Optimization of recirculation from CW header to chamber		
Particulars	Unit	Values
Water Flow	m^3/hr	885
Net Head	M	20.6
Overall efficiency	%	80%
Power saving	kW	69
Operating hrs	hrs/day	24
Annual operating days	days/yr	300
Energy saving	kWh/year	495514

4. Fire & Service Water System

Service water in stage-II of THERMAL PLANT, Barh super thermal power station is being supplied from blow down header. One part of from this header supplies water uses to all plant like washing, cleaning and other usage.

The other part from the header is being supplied to fire water make-up tank and being consumed in plant (as service water) with the help of fire hydrant pumps.

The water flow measurement for the service water & fire water system is shown below:

Table 11: Service Water & Fire Water Distribution

Fire & Service Water

Fire & Service Water		
Particulars	Unit	Values
Total water flow from blow down header	m^3/hr	636
Water flow to fire tank	m^3/hr	245
Plant service usage	m^3/hr	391
Seal water tank	m^3/hr	62
CHP	m^3/hr	30

4.1 Observation & Analysis:

Service Water:

Service water in THERMAL PLANT, Barh is being supplied from blow down from CW pump discharge.

A total quantity of 391 m3/hr is calculated as service water and 30 m3/hr is CHP plant was measured.

Fire Water:

THERMAL PLANT, Barh has fire water system in stage-II is equipped with 3 electrical & 2 diesel hydrant pumps and 2 numbers of jockey pumps. Out of these installation one hydrant pump was in operation during measurement.

Total flow from two numbers of fire hydrant pumps in stage-II was measured 245 m3/hr with a discharge pressure of 10 kg/cm2. It was discussed that mainly one pump is running all the time and other pumps requires to operate on requirement.

As per design only jockey pump along with hydro pneumatic tank should be in service to maintain sufficient pressure in fire water system, but instead of that one fire hydrant pump is in service to maintain pressure.

From the above observation it is clear that fire water is being used even there was no fire incident observed in plant. The fire water (fire pump) is being used as service water as a wrong practice in plant people. This practice must be stopped as there are provision for service water in plant.

Note: The following can be implemented for the reduction of use of fire water as plant service water:

Educate, starting of awareness program, training plant people about the criticality & optimum use of fire water.

5. DM & Potable water system

As discussed in above chapters that raw water from PT pump discharge supplies water to DM clarifier and after the clarification the water is being stored in DM water make-up tank through DM plant process.

DM water from DM water make-up tank fuehrer supplies to process make-up with the help of pumping system called as DM make-up pump. One pump is in operation in general and other pump need to operate if required.

Drinking water (known as potable water) for stage-II is being supplied from PT pump discharge and stored and further supplied to plant over head tanks with the help of pumping system for plant use.

The potable water flow is measured as 25 m3/hr and pump is being operated 10 hrs/day. It was observed that a quantity of 47 m3/hr water is being drained named as LPD drain from Unit #5. This water should be stopped to prevent the DM water loss. The saving calculation is shown below:

Table 12: Stoppage of Unit #5 LPD Drain (DM Water)

Stoppage of Unit #5 LPD Drain (DM Water)

Stoppage of Unit #5 LPD Drain (DM Water)		
Particulars	Unit	Values
Present		
Measured water flow	m^3/hr	47
Operating hours	Hrs/day	24
Annual operating days	Days/yr	300
Estimated water quantity	m^3/day	1128
Estimated water quantity	m^3/yr	338400
Water cost considered	INR/m^3	4
Annual monetary cost	INR/yr	1353600
Proposed		
Water usage quantity (@ 20%)	m^3/hr	9.4
Estimated water quantity	m^3/day	226
Estimated water quantity	m^3/yr	67680
Annual monetary cost	INR/yr	270720
Savings		
Water usage quantity	m^3/hr	37.6
	m^3/day	902
	m^3/yr	270720
Monetary cost	INR/yr	1082880
Investment required	INR	Nil
Simple payback period	months	Immediate

It was also observed that DM water from vacuum pump was drained. The quantity was measured as 2 m3/hr. It should be reduced to 0.5 m3/hr. So that, The water should be collected and recirculated to DM tank and water can be saved. There will be an additional saving of 36 m3/day.

The LPCD (litre per capita per day) of drinking was calculated and is 83 litre/capita/day considering 3000 person in plant with a total water of 25 m3/hr water is being consumed.

The above calculated LPCD is high considering the required amount of water per person per day for drinking. This indicates the opportunity to save water. The further saving for the raw water is calculated and shown below table:

Table 13: Optimization of LPCD of Drinking water

Optimization of plant drinking water consumption		
Particulars	Unit	Values
Present		
Water usage in plant	m^3/hr	25
Daily operating hours	Hrs/day	10
Potable water flow to in plant	Liter/day	250000
Number of plant personals	Numbers	3000
Specific water consumption	liter/capita/day	83
Water cost considered	INR/m^3	4
Annual monetary cost	INR/yr	300000
Proposed		
Specific water consumption	liter/capita/day	30
Number of plant personals	Numbers	3000
Estimated water quantity	Liter/day	90000
Estimated water quantity	m^3/hr	9
Annual monetary cost	INR/yr	108000
Savings		
Drinking water usage in plant	Liter/day	160000
	Liter/hr	6667
	m^3/hr	6.7
Monetary cost	INR/yr	192000
Investment required	INR	500000
Simple Payback period	Months	31

Note: The saving calculation is done considering the LPCD 30 litre/capita/day (considering practical use of water in area like drinking, washing & other uses).

The above mentioned water saving can be achieved and LPCD can be reduced by using flowing means:

Increasing the capacity of water tank of plant.

Provide float valves for all storage tank and stoppage of overflow from the storage tank.

5.1 Suggestions for improvement:

Install a conductivity controller to automatically control blow down. Work with a water treatment specialist to determine the maximum cycles of concentration the cooling tower system can safely achieve and the resulting conductivity (typically measured as micro Siemens per centimetre, µS/cm). A conductivity controller can continuously measure the conductivity of the cooling tower water and discharge water only when the conductivity set point is exceeded.

Install flow meters on make-up and blow down lines. Check the ratio of make-up flow to blow down flow. Then check the ratio of conductivity of blow down water and the make-up water (handheld conductivity meters can be used to determine the relative mineral concentration of the recirculation and make-up water). These ratios should match the target cycles of concentration. If both ratios are not about the same, check the tower for leaks or other unauthorized draw-off. If the system is not operating at, or near, the target cycles of concentration, check system components including conductivity controller, make-up water fill valve, and blow down valve.

Read conductivity and flow meters regularly to quickly identify problems. Keep a log of make-up and blow down quantities (conductivity, and cycles of concentration log book available). Monitor trends to spot deterioration in performance.

6. General Practices in Thermal Power Plant, Barh

Few practices observed in Thermal Plant and few practices which can be improved are listed below:

Table 14: General Practices in Plant

Good Practice Adopted inside the plant
Installation of waste water recycling system
Recirculation of water from Ash dyke
Improvement suggestions
Use of fire pump water (10 kg/cm2) as service/plant usage water
High use of water in Drinking (domestic use) Over flow
observed in ASH Sump
Installation of flow meter for continuous water measurement
Large recirculation water observed at pump Discharge
Cooling tower Below down Continuously
DM water drain observed of power cycle

Maintaining logbook for respective areas for daily water usage pattern

7. Water Conservation measures

7.1 Project – 1: Optimization of Make-up water flow (blow down) in Ash Water Pump House

Present Scenario

Water from ash water recirculation pump is being supplied to Ash water sump. Make-up water quantity of 201 m3/hr is also being supplied to ASH water sump.

Also water is overflowing from the sump to drain. A total quantity of 4824 m3/day water is being supplied as make-up water is ash system.

Proposed Measure

It is suggested to optimize the make-up water by stoppage of overflow from the sump. This will reduce the make-up water consumption to a quantity of 965 m3/day.

Saving Calculation

Particulars	Unit	Present	Proposed	Savings
Blow down Quantity	m^3/hr	201	40.2	160.8
Blow down Quantity (daily)	m^3/day	4824	965	3859.2
Blow down Quantity(yearly)	m^3/yr	1447200	289440	1157760
Monetary cost	INR/yr	5788800	1157760	4631040
Investment	INR	Nil		
Payback period	Months	Immediate		

Water savings : 160.8 m3/hr

Water savings : 3859 m3/day

Investment & Payback Period

Investment : Nil

Payback period : Immediate

Note: It was discussed and observed during the field visit that the corrective measure to reduce the make-up water consumption is being taken **and will be implemented soon.**

7.2 Project – 2: Optimization of HVAC Make-up Water in HVAC system

Present Scenario

Water quantity of 56 m3/hr is being supplied to HVAC system. The total quantity of 1344 m3/day is calculated which is being supplied to HVAC system.

Proposed Measure

It was discussed and agreed by plant people that present water quantity can be reduced 50% of present value. The expected quantity of water saving each 672 m3/day.

Saving Calculation

Particulars	Unit	Present	Proposed	Savings
HVAC make-up water flow	m^3/hr	56	28	28
HVAC make-up water flow (daily)	m^3/day	1344	672	672
HVAC make up-water flow (yearly)	m^3/yr	403200	201600	201600
Monetary cost	INR/yr	1612800	806400	806400
Investment	INR	Nil		
Payback period	Months	Immediate		

Water saving : 28 m3/hr

Water saving : 672 m3/day

Investment & Payback Period

Investment : Nil

Payback period : Immediate

7.3 Project –3: Reduction of LPCD of Plant Drinking Water

Present Scenario

Water flow of quantity of 25 m3/hr is measured for as portable water (Drinking purpose) in the plant. the calculate LPCD for drinking water per day per person considering 3000plant persons per day and ten hours of portable water pump operation. Total portable water consumption is calculated 250 m3/day**.**

Proposed Measure

It is proposed to reduced LPCD 30 (considering practical use of water includes drinking, hand wash and few other uses).the total expected saving each160 m3/day.

Saving Calculation

Particulars	Unit	Present	Proposed	Savings
Drinking water	m^3/hr	25	9	16
Drinking water (daily)	m^3/day	250	90	160
Drinking water(yearly)	m^3/yr	75000	27000	48000
Monetary cost	INR/yr	300000	108000	192000
Investment	INR	500000		
Payback period	Months	31		

Water savings : 16 m3/hr

Water Savings : 160 m3/day

Investment & Payback Period

Investment : 500000

Payback period : 31

7.4 Project – 4: Stoppage of Unit #5 LPD Drain

Present Scenario

It was observed that water quantity of 47 m3/hr is being drained named as LPD drain from nuit#5.the water quantity of 1128 m3/day is being drained.

Proposed Measure

It is suggested to reduce LPD drain water to 226 m3/day (@ 20%) of present water flow. A quantity of 902 m3/day expected to be saved.

Savings

Particulars	Unit	Present	Proposed	Savings
LPD drain flow from U#5	m^3/hr	47.0	9.4	37.6
LPD drain flow from U#5(day)	m^3/day	1128	226	902
LPD drain flow from U#5(Yearly)	m^3/yr	338400	67680	270720
Monetary cost	INR/yr	1353600	270720	1082880
Investment	INR	Nil		
Payback period	Months	Immediate		

7.5 Project – 5: Stoppage of DM water Drain from Vacuum Pumps

Present Scenario

Water quantity of 2 m3/hr is measured to be drained from vacuum pumps.

Proposed Measure

It is suggested to stop/recycle the water in DM clarifier tank. The total quantity of 36 m3/day can be saved.

Saving Calculation

Particulars	Unit	Present	Proposed	Savings
DM water from vacuum	m^3/hr	2.0	0.5	1.5
DM water from vacuum (daily)	m^3/day	48	12	36
DM water from vacuum (yearly)	m^3/yr	14400	3600	10800
Monetary cost	INR/yr	57600	14400	43200
Investment	INR	100000		
Payback period	Months	26		

Water savings : 1.5 m3/hr

Water Savings : 36 m3/day

Investment & Payback Period

Investment : 100000

Payback period : 26

8. Energy conservation Measures

Recirculation of water was observed and measured in various areas/pumping systems of the plant. The recirculation leads to power which is not being utilized for any effective utilization of water and leads to loss of power of pumps and energy loss. It can be optimized/stopped by correction of passing valves or installation of motorize valves.

Below table indicates the summary of energy conservation measures:

Power Losses					
Particulars	Flow	Power	Operating Hrs/day	Annual Op. Days	Energy
	m^3/hr	kW	Hrs/day	Days/yr	kWh/yr
Optimization of recirculation from PT Pump header	80	10	24	300	72852
Optimization of recirculation from Clarifier pumps	209	32	24	300	233067
Optimization of recirculation from CW pumps to chamber	885	69	24	300	495514
Optimization of recirculation from Seal water tanks in PT Pump house	0.5	0.06	24	300	455
Optimization of recirculation of water from HVAC pump header	35	17.31	24	300	124665
Total	**1210**	**129**			**926554**

9. Conclusion

Less than 3 percent of the water on Earth is fresh. Much of that is unreachable in glaciers, icecaps, or deep in the earth. Depletion of these dwindling water supplies degrades the natural environment and can necessitate costly for human kind in future. Water Balancing and Analysis shall be covered the holistic approach towards the limited water resource, distribution and its efficient use to reduce the capital as well as operating costs as an added advantage over the optimized use of water resource with the environmental protection.

The mentioned water conservation opportunity in report is implementable and water saving is quite achievable by implementation of new technology , installation efficient appliances and fixtures in water system, behavioural changes, by educating, creating awareness & training programme at regular interval.

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