Presentation

on

OPERATION AND MAINTENANCE OF WATER SUPPLY SYSTEM

By

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STRUCTURE OF PRESENTATION

- **Key issues regarding water supply scenario around the World**
- **Definition of Operation and Maintenance**
- **Key issues before the water authorities for water supply O & M**
- **Objectives of Operational System and Management**
- O & M of Water Resources for quality and quantity
- O & M of Conveyance system of water resources
- O & M of Water Treatment Plant
- **O & M of service reservoirs and distribution pipeline**
- O & M of **drinking water quality maintaining and surveillance**
- **O & M of billing and collection**
- **O & M of Energy Audit**
- **Water Audit and Leakage Control**
- **System Management**
- **Public Private Partnership (PPP / PSP)**

Highlight of global water scenario

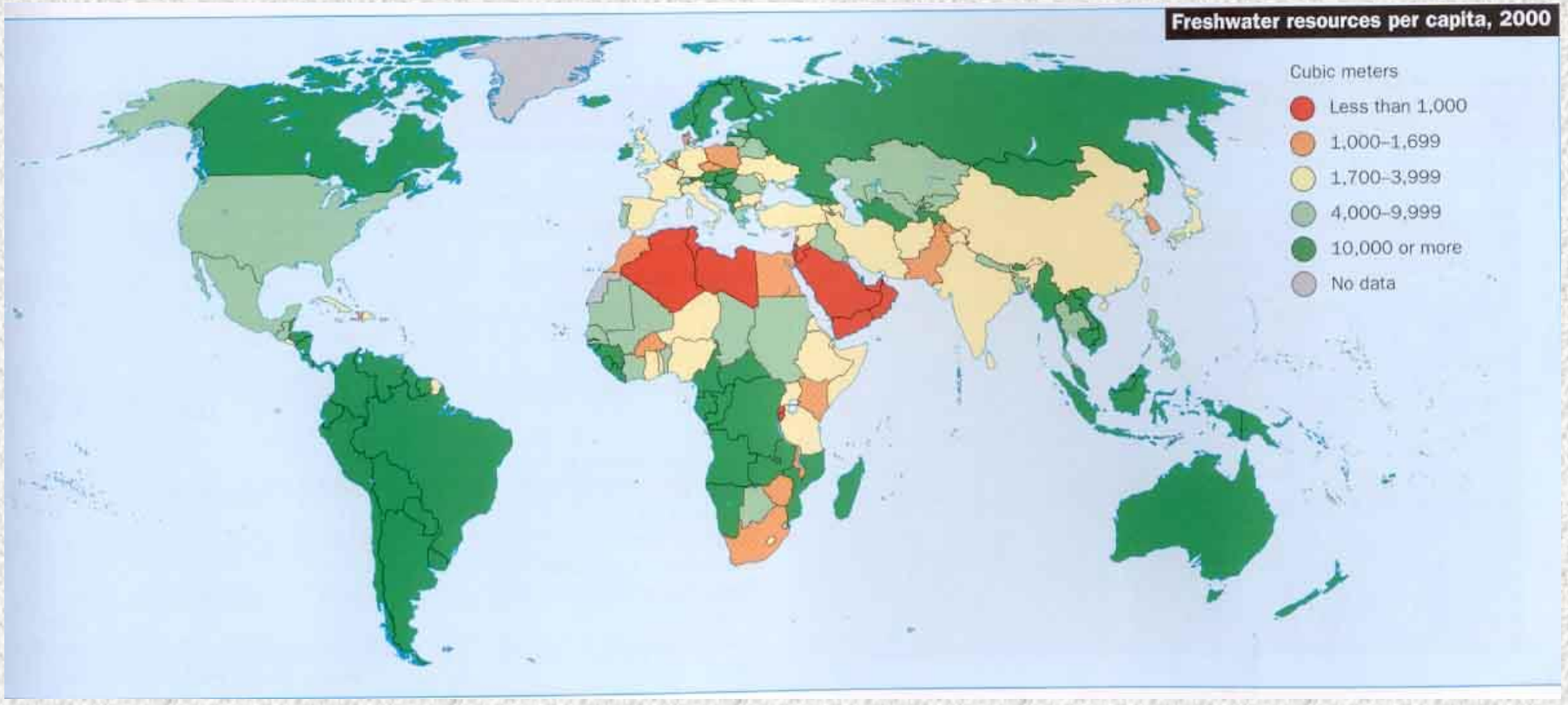
- Water is renewable source but at the same time it is a finite source
- Only less than 1% of the total water is in the form of fresh water resource
- More than 1 billion people lack access to safe water
- Global per capita water supplies have declined by a third over the past 25 years
- 600 million live in countries facing water stress (less then 1700cum of water per person)
- By 2050 the share of world population facing water stress could increase five fold
- World population by 2050 will be 8.8 billion as against 6.1 billion during 2001
- By 2025 nearly 50% of population will be living in urban areas
- The most of the developing countries water supply is intermittent and inadequate quality and quantity
- Un accountably large quantity of water supplied are unaccounted (ranging from 30% to 605 of volume)
- Operating cost are very high

  (for Energy, Chemicals, manpower, Defective equipment and spare parts etc.)

Emerging water shortage

- Water stressed country
  - Annual per capita availability of renewable fresh water in a country or region falls below 1700 Cubic Meters.
- Water starved country
  - Per capita availability falling below 1000 Cubic Meters.
- Absolute scarcity country
  - Per capita availability falling below 500 Cubic Meters.

World Map showing Per Capita Availability



Declining availability of water per capita

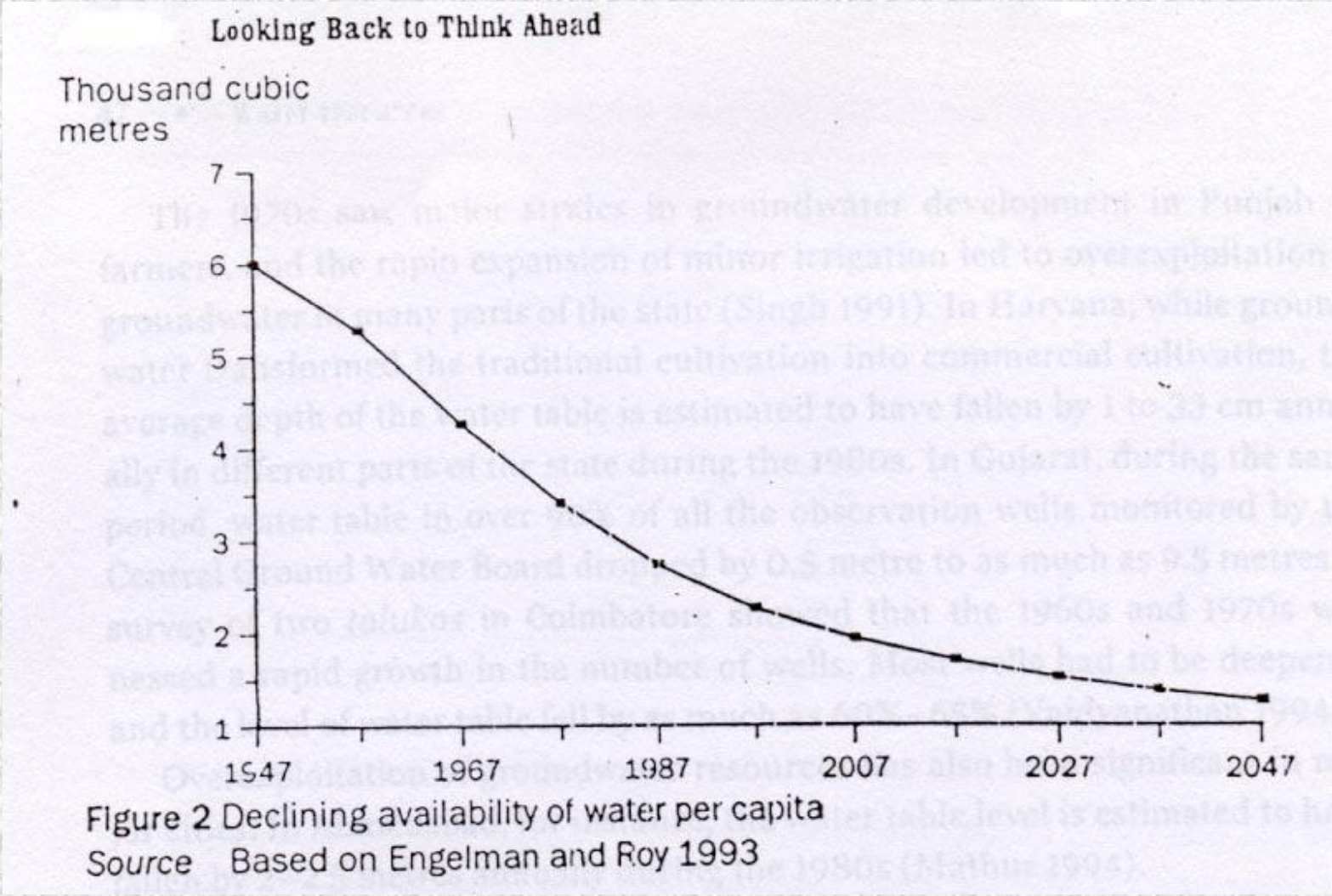


Figure 2 Declining availability of water per capita
Source Based on Engelman and Roy 1993

OPERATION AND MAINTENANCE OF WATER SUPPLY SYSTEM

The objective of the Operational organization will be to ensure the provisions of a continued and satisfactory service to the user of the water system at a minimum cost. The management will provides direction and control; the operators will be responsible for product quality and matching rate of working to requirement; and the maintenance workers will be concerned with the replacement of worn or defective items, so as to ensure continuous serviceability. These duties may some time over lap in the interest of economy.

KEY ISSUES

Which contribute for poor performance by water supply and sanitation agencies

- Lack of leadership and poor MIS
- Lack of operation and management tool for programming and performance
- Lack of information to guide the formulation of operation and maintenance plans and to identify staffing profiles and training needs (such as basic manuals inventories of equipments layout drawings of construction place and maps showing locations)
- Lack of conservation of effective maintenance procedure to minimize break downs and prolong operational life of the service.
- Lack of effective preventive maintenance procedures to minimize breakdown and to prolong the operational life of service
- Lack of consideration of operation and maintenance requirements during project planning design and Construction (Training for operation and maintenance staff equipment for O & M such as tools, transport and stores – definition and standards

MAINTENANCE

Effective maintenance policy will be facilitated if

- Management should state its maintenance policy, its objective and its attitude.
- Responsibility should be clearly depend and vested with a competent persons
- Adequate equipment and material are scheduled, provided and themselves maintenance
- Record and report facilitate control

CLASSES OF MAINTENANCE

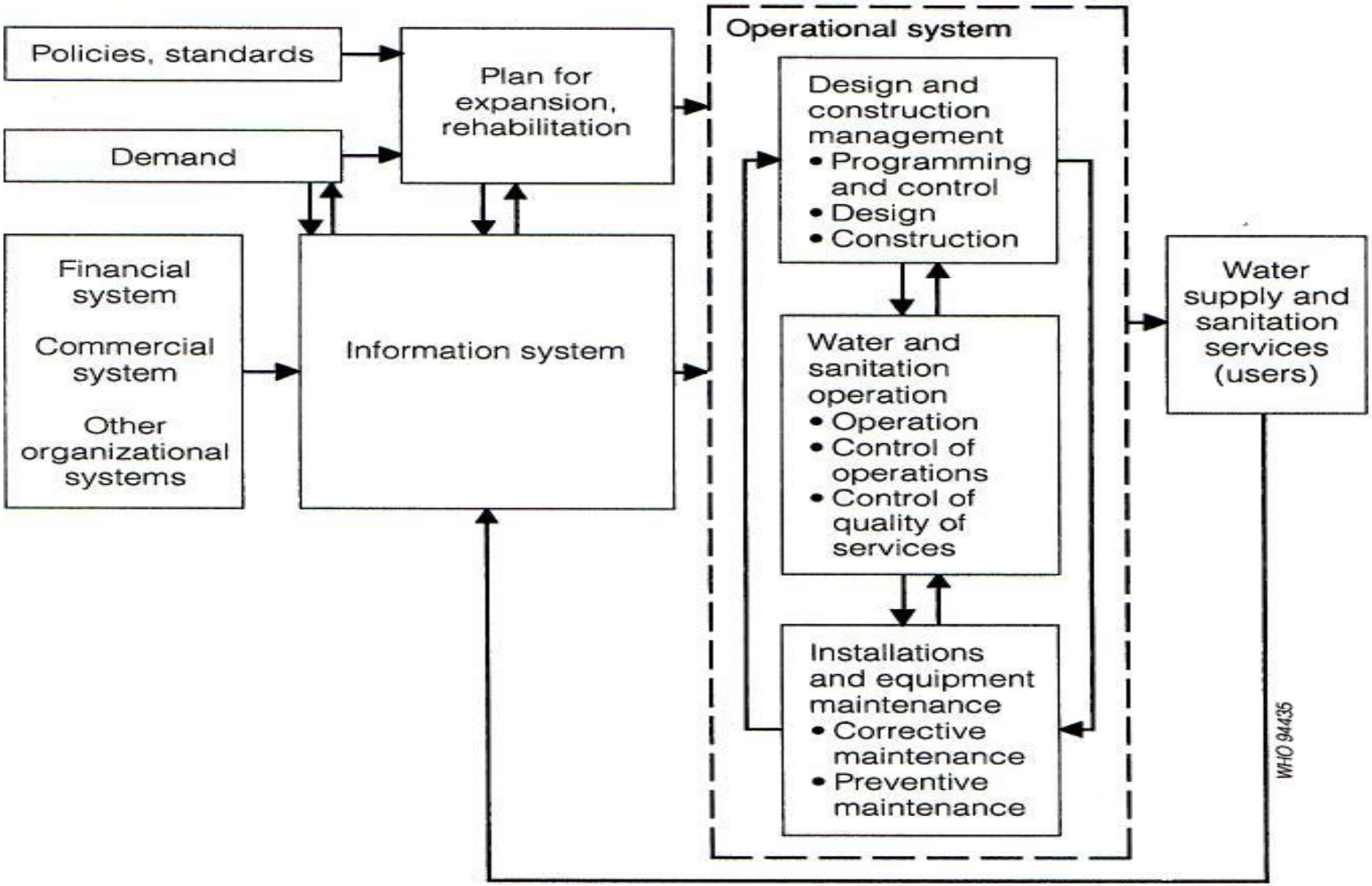
- Operational maintenance carried out on a day to day basis, such as cleaning, minor adjustment and lubricating
- Corrective or breakdown maintenance after fault or breakdown
- Planned / preventive maintenance (Regular maintenance and parts replacement in accordance with programme based on calendar time or operating hours).

OPERATION SYSTEM

The Objectives of the Operation Systems are

- To supply plans and designs for the construction work necessary for provision of the agency a services, in line with technical, social and financial requirements
- To ensure that construction work complies with the plans and designs of the agency and is appropriate to the needs of the community with regard to health, quality, functioning, timing and cost.
- To establish standards for the delivery of services that are satisfactory in respect of quality, quantity, continuity, coverage and cost;
- To maintain the installations and equipment in a condition that will ensure they can be operated satisfactorily, function efficiently and continuously and last as long as possible at lowest cost;
- To produce information on the water supply and sanitation installations and their component units, with specific reference to their functioning and their adequacy to meet the needs of users, thus enabling the agency to evaluate how well the installations work and how effective its services are

Fig. 2
Operational system



OPERATION SYSTEM

The Specific Objectives of the Subsystem are

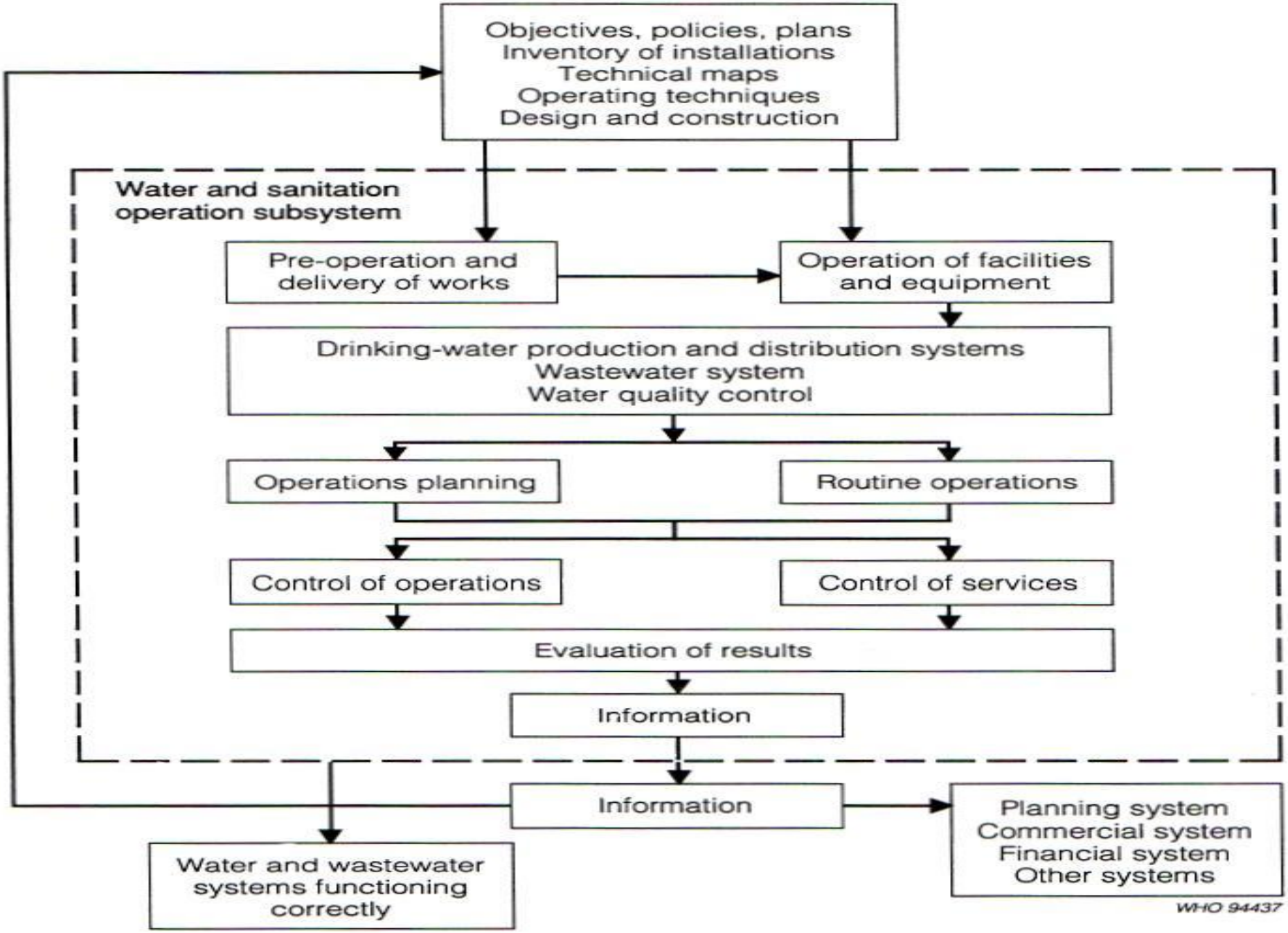
- To operate the facilities and carryout the process necessary to deliver drinking water and sanitation services with the greatest efficiency, safety and economy;

- To ensure the quality of the water (potability) and of the services delivered (quantity, pressure, continuity);

- To protect public health and the environment by monitoring the quality and quantity of sewage effluent discharges;

- To monitor the water supply and sanitation installations in general and their components in particular, in terms of how well they function and how well they meet requirements, so that their effectiveness can be evaluated.

Water and sanitation operation subsystem



OPERATION SYSTEM

In carrying out preventive and corrective maintenance, the subsystem's activities – whether managerial or operational fulfill the following tasks

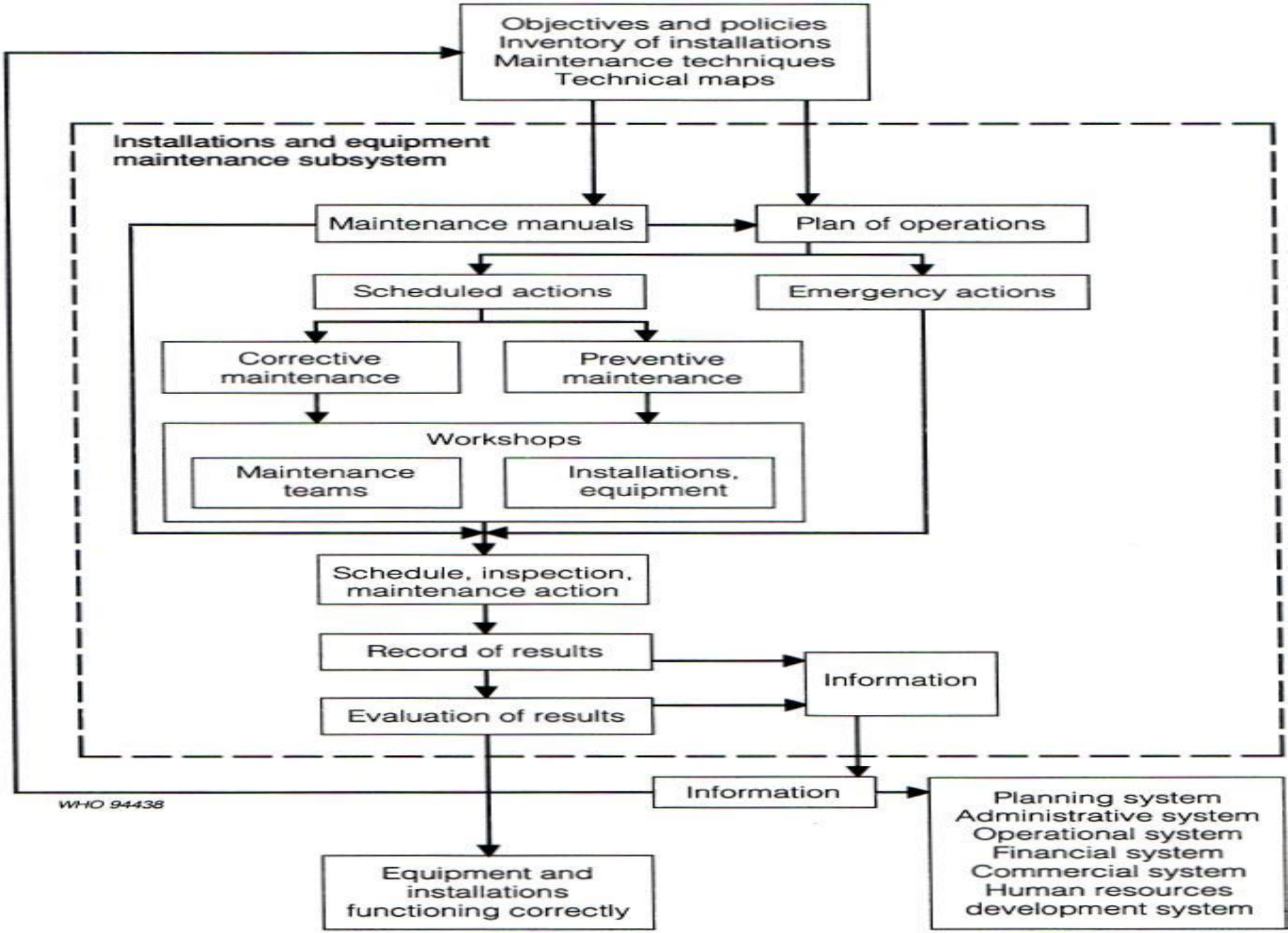
- Actions are performed on the components and equipment of the agency's installations to ensure their cost effective operation

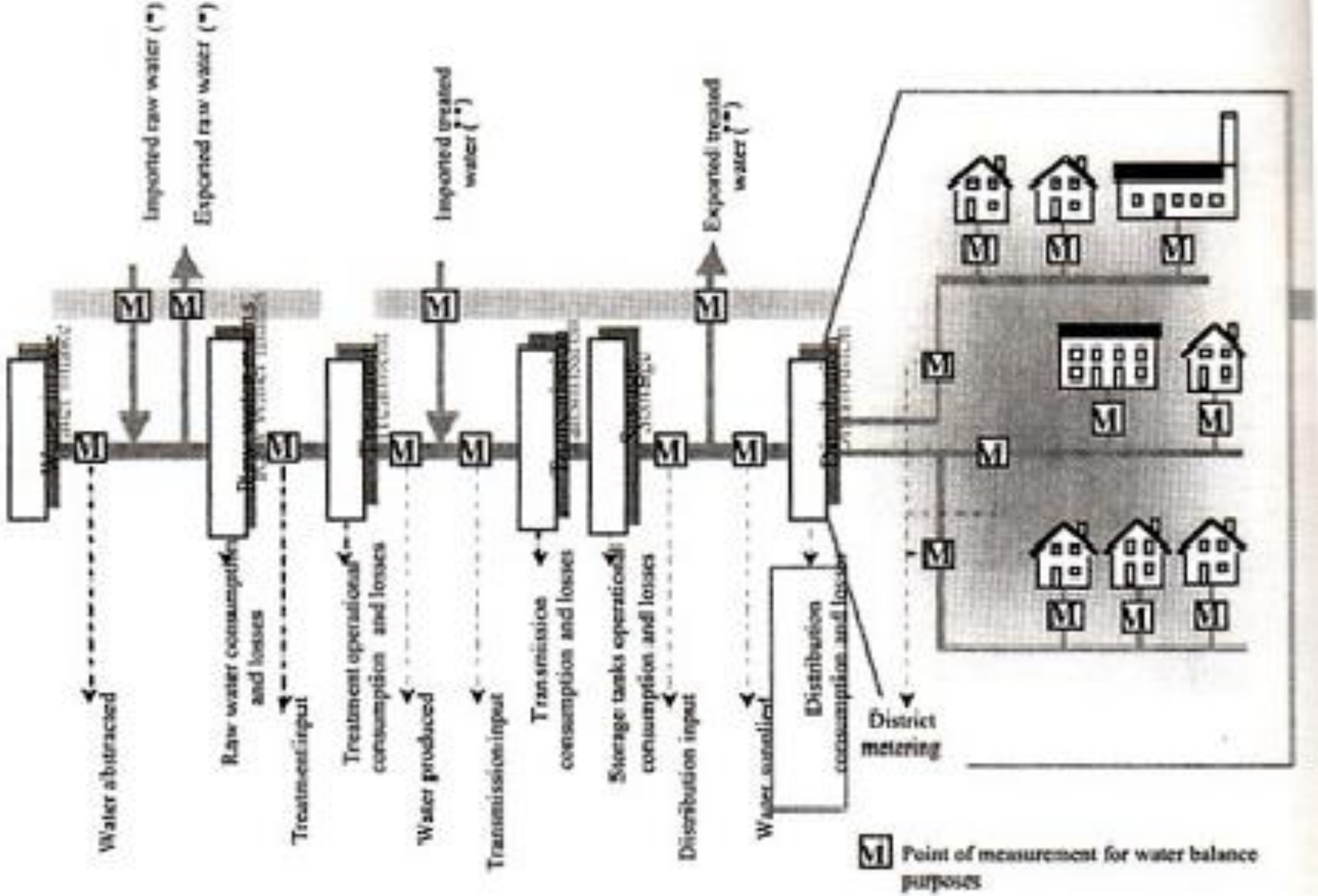
- Maintenance work performed on the installations and equipment is monitored for quality and timeliness

- Maintenance is controlled and monitored in order to measure the performance of equipment and installations, estimate their useful life and provide for their replacement when indicated by cost benefit studies or other technical considerations.

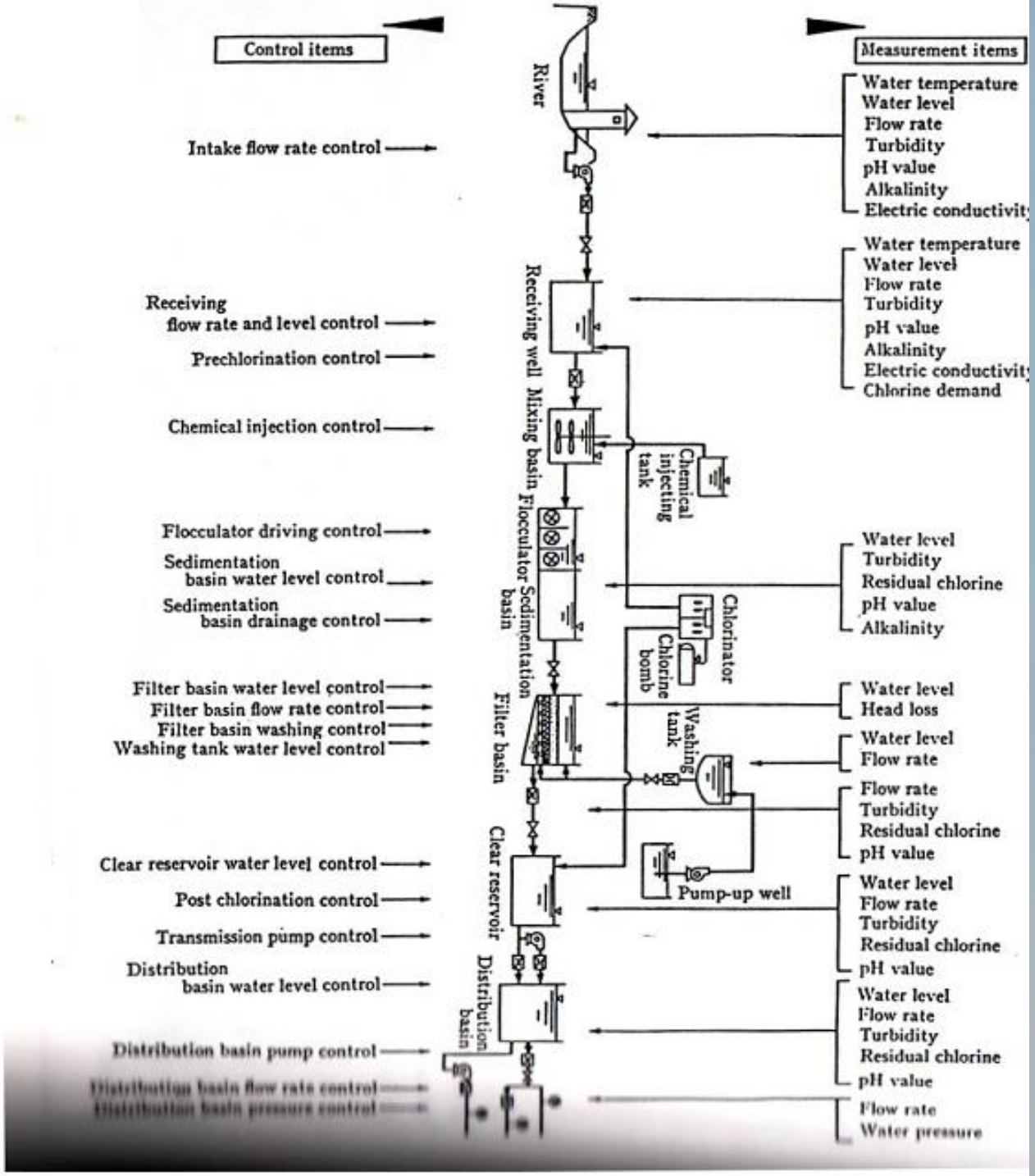
- Reliable, adequate and up-to-date information is collected, recorded and processed for the planning and proper execution of preventive and corrective maintenance activities

Installations and equipment maintenance subsystem





(*) - can be located anywhere between the water intake and the treatment
(**) - can be located anywhere downstream treatment



Flow Sheet of Measurement and control of water works facilities

Operation and Maintenance of Water Resources

a) Surface water and Ground water

a) **Surface Water**

a-1 Intake Structure and its maintenance

a-2 Water quality maintenance

a-3 Safety and O & M

b) **Ground water**

b-1 Conservation of ground water

b-2 Rehabilitation measures of tube well

b-3 Encrustation of Tube well pipe

b-4 Artificial recharge of ground water

Operation and Maintenance of Water Resources

a) Transmission of water through Channels / Pipeline

b) **Channels**

C-1 Flow measuring devices

C-2 Lining inspection

C-3 Seepage flow embankment

C-4 Weed removal

C-5 Cross drainage works inspection

D) Pipeline

D-1 Flow measuring devices

D-2 Leakages and air valves inspection

D-3 Normal operation and maintenance of the pipeline

D-4 Maintenance schedules and prevention maintenance

D-5 Flushing of pipeline.

D-6 O & M of telemetry and SCADA system

300,000 m3/d Water treatment plant at T.K. Hally with Pulsator Technology

MAINTENANCE OF WATER TREATMENT PLANTS

1) Slow Sand Filter 2) Rapid sand filters 3) Pressure filters etc.,

Rapid Sand filters

- Raw water quality testing
- Using of chemical coagulant of optimum dosage.
- Flash mixer functions and its operation and maintenance
- Clarifloculators / Sedimentation basin function for proper operation
- Quality of water leaving settling tanks / clarifloculators
- Preventive maintenance all moving and operational parts as per design and manual supplied.

MAINTENANCE

Water treatment plants

Slow Sand Filter Rapid sand filters Pressure filters etc.,

Filtration Units

- Verification of loading rates Rate of flow to filters and loss of head gauge
- Regular verification of loss head in the filters, if no SCADA for back washing of filters
- Monitoring the Quality of water received from filters
- Monitoring filter media and media's if it is a single media, dual media, Multimedia regarding the effective size and the uniformity co-efficient of the filter media respectively.

MAINTENANCE

Water treatment plants

Slow Sand Filter Rapid sand filters Pressure filters etc.,

- Management information systems of each filters when backwashed and time and date and operation made.
- Preventive maintenance of all the mechanical, electrical equipments
- If SCADA Automation is involved regular preventive maintenance from the authorised company for all the spares replacement
- Online monitoring of all the parameters at each stage of water treatment plant.

SERVICE RESERVOIRS AND DISTRIBUTION PIPELINE

- **Service Reservoir**

  - ❖ Maintaining levels in the reservoir
  - ❖ Sampling water quality, cleaning of reservoir
  - ❖ Normal O & M Service reservoir, checking of condition of reservoir and its Appurtenances
  - ❖ Maintenance records of levels and other details
  - ❖ Maintenance of the inlet and outlet valves
  - ❖ Maintenance of Booster chlorinators wherever installed
  - ❖ Maintenance of civil structure of the reservoir

7.9.1 CHECK LISTS FOR CLEAR WATER SUMP AND RESERVOIR

S. No.	Checks required/undertaken	Status	Frequency of *reporting**
1.	Proper closure of washout valves; any abrupt stoppage during operation.		
2.	Proper operation of inlet valves; any abrupt stoppage during operation.		
3.	Proper operation of outlet valves; any abrupt stoppage during operation.		
4.	Proper operation of bye pass valves; any abrupt stoppage during operation.		
5.	Does any valve pass water even after closure.		
6.	Leaks through valves; glands and bolts and nuts.		
7.	Leaks through pipes and joints at SR.		
8.	Status of valve chambers and their covers.		
9.	Status of finial ventilators; fly proof mesh intact or is to be replaced.		
10.	Status of manhole covers; are they corroded?		
11.	Functioning of water level indicators.		
12.	Functioning of flow meters.		
13.	Status of ladders and railing; are they corroded?		
14.	Check whether quality of the water in the SR is OK.		
15.	Possibility of SR water getting polluted.		
16.	Check for the need for cleaning and disinfecting the SR.		
17.	Check for the presence of residual chlorine in the water stored in SR.		
18.	Check for signs of corrosion of interior of roof due to chlorine.		

TROUBLE SHOOTING CHART FOR VACUUM TYPE CHLORINATOR

Trouble	Cause	Remedy
1. Required gas flow not achieved at start-up.	a. Insufficient ejector vacuum caused by insufficient water supply by pressure or excessive back pressure. b. Leakage at vacuum line connection at outlet from flowmeter, rate control valve, differential from flowmeter, differential pressure regulator, and/or inlet to ejector. c. Vacuum line(s) if flexible, crimped.	a. Refer to Trouble at S.no.6. b. Inspect each connection and remake if necessary. c. Replace vacuum tubing and arrange line(s) to eliminate crimping.
2. Required gas flow rate is not achieved on start-up following an extended period of shutdown.	a. Insufficient ejector vacuum. b. Leakage at vacuum line connection at outlet of flowmeter, rate control valve, differential pressure regulator, or inlet to ejector. c. Vacuum line(s), if flexible, crimped. d. Leakage around flowmeter gaskets.	a. Refer to Trouble at S.no.6. b. Inspect each connection and remake if necessary. c. Replace vacuum tubing and arrange line(s) to eliminate crimping. d. Inspect and align flowmeter or replace gaskets.
3. Flowmeter float observed bouncing and/or maximum gas flow cannot be achieved during normal operation.	a. Gas inlet filter of vacuum regulator dirty. b. Rate valve dirty. c. Flowmeter dirty. d. Ejector water supply pressure fluctuating too wide (float bounce) or insufficient ejector vacuum.	a. Replace gas inlet filter assembly. b. Clean rate valve. c. Clean flowmeter. d. Correct water supply pressure as necessary.
4. Flowmeter fails to indicate gas flow during normal operation but there is no out-of-gas indication.	a. Rate valve plugged. b. Gas flowmeter plugged. c. Vacuum lines, if flexible, crimped.	a. Clean rate valve. b. Clean gas flowmeter. c. Replace vacuum tubing and re-arrange lines to eliminate crimping.
5. No gas indication during normal operation.	a. Gas supply valve(s) closed. b. Gas supply exhausted. c. Clogging of filter in vacuum regulator.	a. Open gas supply valves. b. Replenish gas supply. c. Replace filter.

8.13.2 CHECK LIST Distribution System

S. No.	Checks required/undertaken	Status	Suggested frequency of reporting
1.	Check whether the Operation of valves is smooth without any abrupt stoppage during closure.		
2.	Check whether closure of a valve results in complete stoppage of flow or if any flow passes the valve (passing valve).		
3.	Check for status of scouring and then proper closure of washout valves.		
4.	Check for leaks through pipes.		
5.	Check for leakage through valves at gland, bolts or any other place.		
6.	Check for leaks at the appurtenances.		
7.	Check for any signs of corrosion of pipelines.		
8.	Check for the status of Manhole covers over the chambers; are they corroded.		
9.	Inspect for any possibilities of pollution of the distribution system water stored.		
10.	Status of out-fall drain for scour and overflow.		
11.	Assess the need for painting of the piping work.		
12.	Check for availability of spares for valves and pipes and jointing materials.		
13.	Review the method of giving consumer connections in the field.		
14.	Preparation of water budget for each zone served by one reservoir.		
15.	Number of connections given.		
16.	Number of meters out of order.		
17.	Status of hydrants and PSPs.		
18.	Status of Distribution System.		

DRINKING WATER QUALITY MAINTAINING AND SURVEILLANCE

- Testing water quality as CPHEEO standards both at head works and also at consumer point.
- Quality of sampling, testing, establishing a very high standards at number of sampling in distribution as per WHO norms, fixing a surveillance agency for testing independently.
- Sanitary survey and dead end water quality sampling.
- Analyzing of results, interpretation of results and communication to inspection zonal heads
- Assessment of microbial water quality

300,000 m3/d Pump House at T.K. Hally
With Automation, SCADA and Telemetry

FLOW METERS, INSTRUMENTATION, TELEMENTARY AND SCADA

- **Types of flow meters such as**
  - **Differential pressure** like Venturi meters, Pitot tube, Orifice flow meters
  - **Linear flow meters** like turbine wheel flow, Vortex flow meter, magnetic flow meter, Ultrasonic flow meters.
- **Water Meters**
  - Installation, testing and calibration, repairs and maintenance, automatic water meter reading, selection of water meters.
- Instrumentation
  - Reservoir levels, pressure in pipeline, flow measurements, other electrical readings

FLOW METERS, INSTRUMENTATION, TELEMENTARY AND SCADA

- **Online measurement**
  - ❖ Residual chlorine, Turbidity pH etc.,
- **Automation and SCADA**
  - ❖ Water treatment plants monitoring through central control by automation and SCADA at flow measurement, chemical mixing, backwashing of filters, measuring key parameters at each stage of treatment and alarming signals whenever reaches beyond set limits, operation of mechanical equipments etc.

BILLING AND COLLECTION

Revenue Management

- **Tariff Fixing**
  - Operational Cost, Establishment Cost, Depreciation cost, Debt servicing and Asset replacement fund etc.
- **Categories of consumers for billing**
  - Domestic, Non Domestic, Industries, Defence / Railways,
  - Bulk Consumer like Multi storied building etc
- **Methods of water charges**
  - Metered, Non metered
- **Generation of bills**
  - Monthly for metered consumers
  - Fixed charges may be quarterly / bi monthly
- **Collection of water charges**
  - Manually through counters
  - Through Banks
  - Through KIOSKS
- **Computerised billing advantages**
  - Preparation of DCB statements

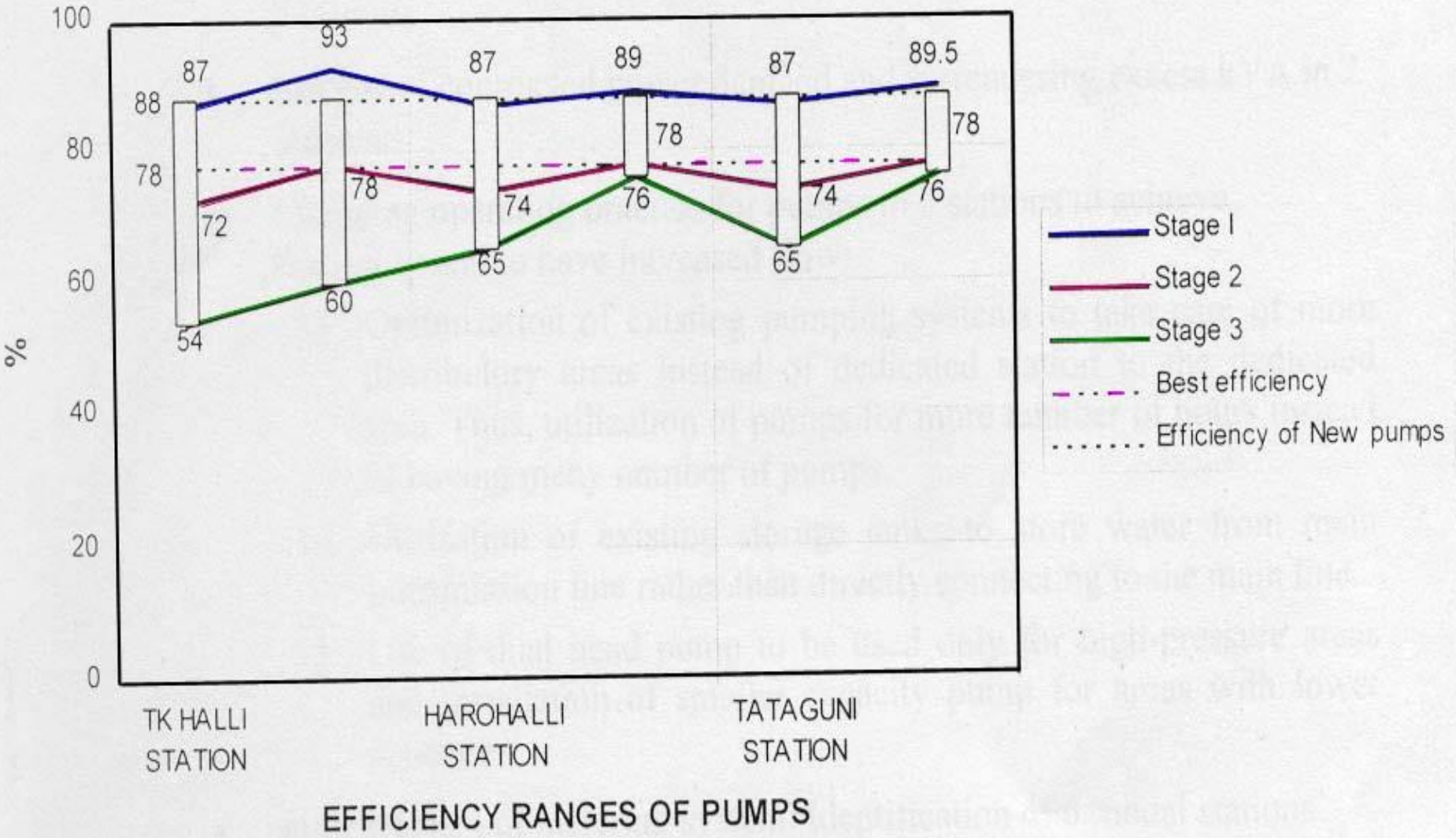
Customer friendly initiatives

KIOSK MACHINE

ENERGY AUDIT

- Study of pump efficiency with reference original Pump discharge curves
- Power factor verification and improvement
- Verifying transformers loading, relays in annunciation panels of high efficiency

PUMP EFFICIENCIES



EFFICIENCY RANGES OF PUMPS

Combined Efficiency Performance of Pumps

	Stage I	Stage II	Stage III
Tataguni			
Efficiency (η)	65 – 76%	74 – 78%	87– 89.5%
Dip compared with best efficiency	2 – 13%	Upto 6%	-
Dip compared with new pumps	7 – 18%	Upto 11%	-
Harohally			
Efficiency (η)	65 – 76%	-	87 89%
Dip compared with best efficiency	2 – 13%	-	
Dip compared with new pumps	7 – 18%	-	
T.K. Halli			
Efficiency (η)	54 – 60%	72 – 78%	87 – 93%
Dip compared with best efficiency	18 – 24%	Upto 6%	
Dip compared with new pumps	23 – 29%	Upto 11%	

Source : Ibid

AFTER IMPLEMENTATION OF TERI RECOMMENDATION

Sl. No.	Particulars	Stage - I	Stage - II	Total
1	Extra water (ML) annually	(+) 3960	(+) 3805	(+) 7765
2	Energy savings annually (lakh units) - base old system	3 : (-) 165.81	3 : (-) 192.28	3 : (-) 358.09
3	Cost of energy saved at Rs.2.75 per unit (Rs. Lakh)	3 : (-) 455.97	3 : (-) 528.77	3 : (-) 984.74

RECOMMENDATIONS OF THE FIRST ENERGY AUDIT

- Replacement of Stage I and II pumps to 84.5% efficiency pumps @ Rs.1.5 Million / pump. It was felt that rewinding of the pumps would not be very effective in increasing their efficiencies.

- Stage III requires no replacement of pumps.

- **A total of 30 pumps (including the stand by pumps) to be replaced over a two-year period.**

- Other recommendations for renovation / modernization like transformer load management, replacement of mechanical meters with electronic meters, installation of HT capacitor banks and change in operating characteristics.

RECOMMENDATIONS OF THE ENERGY AUDIT BY TERI IN 1997

- Replacing all of the pumps in the system with more modern pumps of higher efficiency (pumps efficiency was increased from 82% to 88%).

- The new pumps are fitted with larger impellers, so that the design duty can be achieved when running at a reduced frequency of 48 Hz in lieu of 50 Hz (the power supply frequency drops to 48 Hz approx. 85% of the time). With effect from January 2003, the grid frequency is being maintained between 49.5 to 50 Hz.

- Installation of capacitor banks to increase the power factor to a minimum of 0.9 at all pumping stations to gain savings in energy demand costs.

- Installation of automatic transformer tap changing at all pumping stations to produce a constant 6.6 kV at the pump motors, even though there could be a drop in the 66 kV supply to 60 kV.

WATER AUDIT AND LEAKAGE CONTROL

- Importance of water audit study
- What is physical loss and apparent loss in the system
- Various technologies available in identification of hidden loss in the system
- Economics in reducing un-accounted water

on

Leak Detection

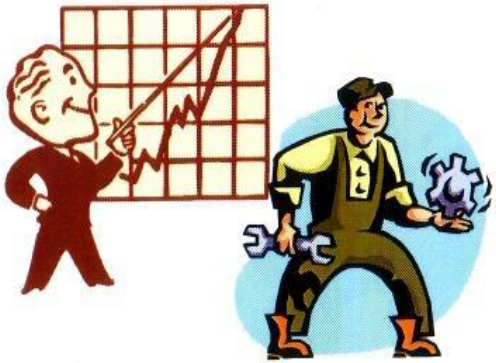
AND

Rectification Methods for UFW

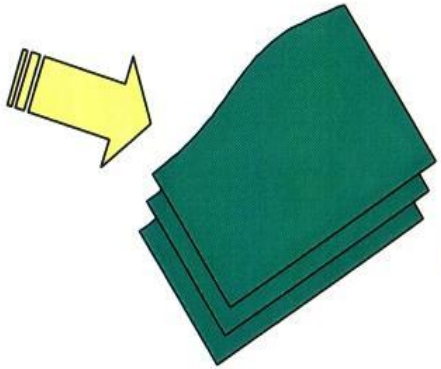
THE PROCESS OF STANDARD LEAK DETECTION AND NECESSARY INSTRUMENTS

The process of water leak detection.	The contents of main work.
The partition of detection area and the plan of operation process.	1. To check up the utility map. 2. To divide an area into blocks. 3. To make a list of operation process.
The preliminary investigation of utilities.	1. To inspect each fitting in accordance with the utility map. 2. To confirm the exact location of each pipeline and fitting. 3. To investigate circumstances around the site.
The acoustic inspection by listening to sound from the pipe fittings.	1. To make the acoustic inspection at every fitting such as Fire-hydrant, Control Valve and Stop Valve. 2. To locate the buried valve and excavate it to inspect.
To measure the midnight minimum flow.	1. To close all of the valves to block the area of leak detection work. 2. To measure the midnight minimum flow into the blocked area.
The acoustic leak detection along the buried pipelines. NOTE: In case of the leak more than 25%.	1. One group consisting of two operators performs the acoustic leak detection along the buried Pipelines at night. (3.5 km per eight hours on an average)
The leak detection with the Leak Noise Correlator. NOTE: In case of the leak less than 25%.	1. Two operators perform the leak detection work in the daytime. (5 km per eight hours on an average)
To confirm the exact point of leak from the ground-surface.	1. To locate the neighbouring utilities other than the water pipeline. 2. To locate the exact point of the maximum leak noise on the ground-surface. 3. To make the bore-holes to determine one leak point with the sound stick.
To prepare the report indicating the leak locations.	1. To indicate clearly the leak location as one point by mentioning the street number and the land-mark.
To measure again the midnight minimum flow.	1. After repairing all of defective points, measure the midnight minimum flow for evaluating the good result by the leak detection and repair works.

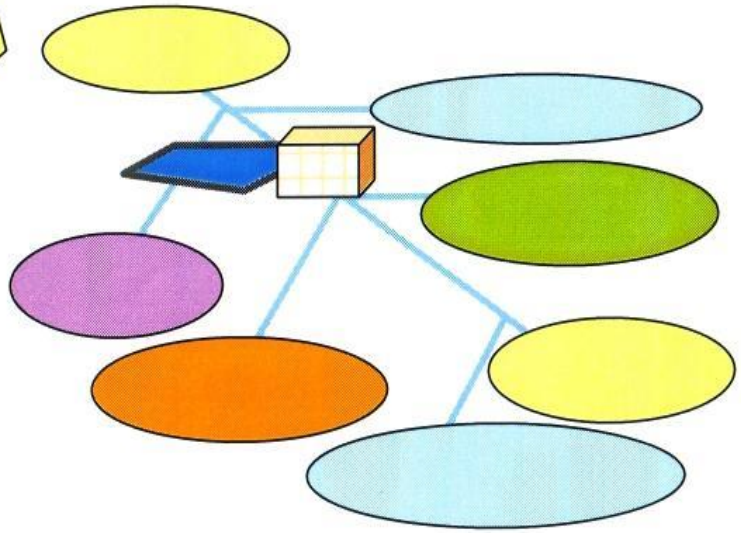
Preparation



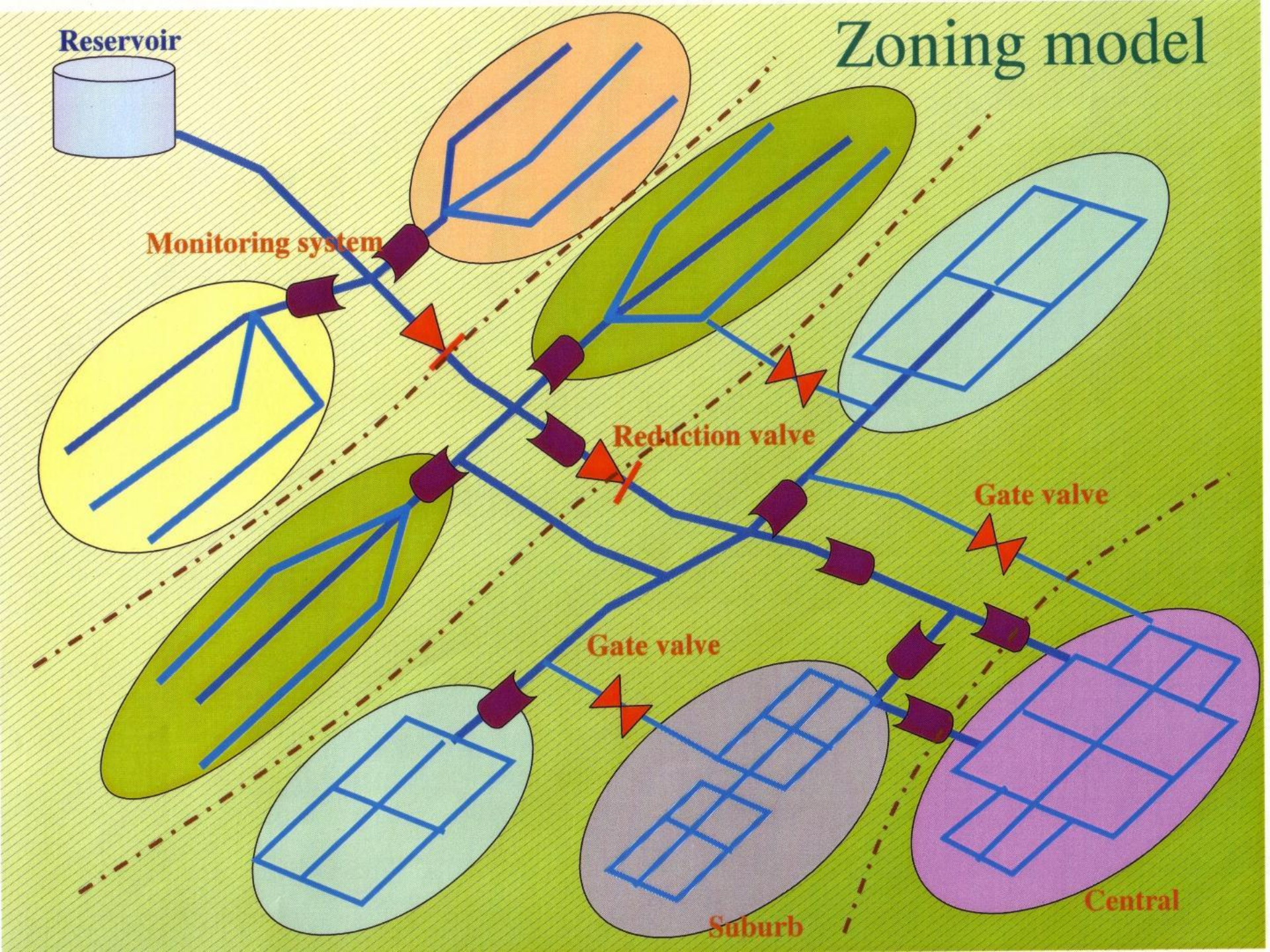
Organize the UFW section



Drawing ·Ledger



Design of Zone & Block


Zoning model
Reservoir
Monitoring system
Reduction valve
Gate valve
Gate valve
Suburb
Central

Measurement inflow

In the reservoir

At the distribution pipe

At the distribution mains

SYSTEM MANAGEMENT

- **Management information System**
  - ❖ Management levels : Senior, Middle and Operational Management
- **Management indicators**
  - ❖ Performance indicators and Bench marking
  - ❖ Safety and Security in maintenance of plant and accessories
  - ❖ Disaster mitigation management, Drought mitigation management
- **Financial information System**
  - ❖ Such as demand Collection and Balance, budget process, O & M experiences and surplus deficit etc.

ANNEXURE 14.1

PERFORMANCE INDICATORS

S. No.	Indicator	Method of calculation	Remarks
1.	Coverage of area with water supply	Area with water supply/Total area	Identify areas to be provided water supply in the future plans
2.	Index of population covered by service (%)	Length of streets with water pipelines/total length of streets	Is extension of main required?
3.	Percent covered by service	Population served/total population	How to serve the un-served population?
4.	Service level	Quantity of water produced per day/population served	
4.1	Index of population served by public taps (%)	Population served by public taps/total population	
4.2	Average population served by one public tap	Population served by public taps/number of public taps	
5.1	Index of water distributed or measured (%)	Quantity measured or distributed/quantity produced	
5.2	Index of water distributed through public taps (unmeasured %)	Quantity of water supplied through public taps/total quantity of water	
6.	Water not accounted for	Water bills/water produced	
7.	Staff productivity	Number of connection/ Number of Staff	
8.	Operational costs per staff	Total O&M cost/Staff number	
9.	Operational cost per connection	Total O&M cost/number of connections	
10.	Operational cost per KL of water produced	O&M Cost/quantity of water produced in KL	
11.	Production cost	Cost of production/quantity of water produced in KL	
12.	Distribution cost	Distribution cost/quantity of water produced in KL	
13.	Index of use of production or treatment capacity	Quantity of water produced/ installed capacity	
14.	Index of use of transmission line capacity	Quantity of water transmitted/ designed transmission capacity	
15.	Index of use of pumping station capacity	Quantity of water pumped per day/installed capacity	
16.	Index of use of reservoir capacity	Average quantity of water distributed/available storage capacity of reservoirs	

17.	Index of use of energy at treatment plant	Energy consumed per day/ quantity of water pumped per day i.e KW/KL pumped	Is there a need for an energy audit by an external agency?
18.	Index of use of energy at treatment plant	Energy consumer per day/ quantity of water treated per day i.e. KW/KL treated	
19.	Index of use of Coagulant at treatment plant	Coagulant consumed per day/ Quantity of water treated per day (mg/L)	
20	Index of treatment losses	Treated water produced/raw water received	
21.	Index of water quality at treatment plant	Percent samples with greater than permissible turbidity	
22.	Index of unwholesome samples in distribution system	Percent unwholesome samples	
23.	Index of disinfection at treatment plant	Percent samples with less than desired residual chlorine	
24.	Index of use of chlorine at treatment plant	Chlorine consumed per day/ quantity of water treated per day (mg/L)	
25.	Index of power failures at pumping stations	Hours of pumping lost/ 24 hours or designed pumping hours	
26.	Index of other failures at pumping stations	Hours of pumping lost due to reasons other than power failure/24 hours or designed pumping hours	
27.	Index of failure of pumping mains	Hours of pumping lost due to transmission line defects/ 24 hours or designed pumping hours	
28.	Mean time between failure of pumping equipment	Average of time interval between two successive failures of pumping equipment in a year	
29.	Mean time between failure of pumping mains	Average of time interval between two successive failures of pumping mains in a year	
30.	Index of failures		
30.1	Power	Power failures/total failures	
30.2	Pumping equipment	Equipment failures/Total failures	Is the equipment reliable or obsolete
30.3	Pumping main	Pumping main failure/Total failures	

PUBLIC PRIVATE PARTNERSHIP (PPP / PSP)

- **Examine various PSP / PPP options in hierarchy such as**
  - Service Contract
  - Management Contract
  - Lease (affermage)
  - Concession Contract
  - BOOT / BOT / ROT etc
  - Divestiture
- **Advantages and disadvantages in each case**
- **Few examples in each case**
- **Many proposal failures in India and reason**

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