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Study Report (Final)

# DEVELOPMENT OF WATER SAFETY PLAN & WATER CONTAMINATION CONTROL PLAN FOR 05 MUNICIPAL COMMITTEES

## JOHI, MEHAR, KHAIRPUR NATHAN SHAH, KAMBAR & SHAHDADKOT


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**5th July, 2021**

**To,**

**The Program Director**
Program Management Unit (PMU) – Sindh MSDP
Planning & Development Department
Government of Sindh, Karachi
D-18 Block 2, Kehkashan, Clifton, Karachi

**SUBJECT:** **SUBMISSION OF STUDY ON DEVELOPMENT OF WATER SAFETY PLAN & WATER CONTAMINATION CONTROL PLAN FOR 05 MUNICIPAL COMMITTEES (JOHI, MEHAR, KHAIRPUR NATHAN SHAH, KAMBAR AND SHAHDADKOT) DEVELOPED UNDER LGSA PROJECT, MSDP**

**Dear Sir,**

We are thankful for your approval of Study on Development of Water Safety Plan & Water Contamination Control Plan for 05 Municipal Committees (Johi, Mehar, Khairpur Nathan Shah, Kambar and Shahdadkot) during the Quality Assurance Committee (QAC) meeting held on June 25, 2021.

We are pleased to submit final version of this Study for your record

We will be glad to provide any additional information if required.

Looking forward to cooperating with you.

With Best Regards

**Avais Ahmed Memon**
Chief Operating Officer
Management & Development Center (MDC)
Focal Person (LGSA), MSDP

**Cc to:**

- Director General (Works), PMU-Sindh MSDP, Karachi.
- Director (Reforms), PMU-Sindh MSDP, Karachi.
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# EXECUTIVE SUMMARY

Water Safety Plan; consistently ensuring the safety of drinking-water supply through using a comprehensive risk assessment and risk management approach that encompasses all steps in the water supply from catchment to the consumer. WSP addresses the overall issues of complete program wherein delivery of water from source to the end user mapped through different means to assess the risk of water contamination at various levels.

The objectives of proposed Water Safety Plan for **5 Municipal Committees i.e Mehar, Khairpur Nathan Shah, Johi, Kamber and Shahdadkot** are to ensure safe drinking water through the best water supply practices that are to:

- Prevent contamination of water at source;
- Treat the water to reduce or remove contamination to the extent necessary to meet the WHO water quality standards;
- Prevent re-contamination during storage, distribution and handling of drinking water.

The water distribution network, mostly contains water supply lines and pumping stations serving population. After filtration, the treated water is supplied. While mostly, the pumping stations included in the system are serving mainly as intermediate and booster stations. The water is pumped either directly into the distribution mains or goes to a number of High Service Reservoirs (HSR) or Low Service Reservoirs (LSR).

The department of taxation is responsible for billing, recovery/ collection and fixing water rates, which is functioning fairly.

The supply is not meeting the demand as reduces due to water losses, leakages and electric load shedding resulting the short fall.

To determine the risks, the water quality analysis showed that the parameters (physical, chemical and biological) are not meeting the drinking water standards. The reason is that the water is not properly treated. Second reason is that once the water is pumped into the water distribution network, its quality further deteriorates which is a hazard for the community.

Due to lack of efficient operations and maintenance, the distribution network becomes weak resulting into leakages, which is major cause of contamination creating health hazards.

Under the WSP, different types of control measures and Standard Operating Procedures (SOPs) developed separately for sources, lagoons, treatment plants and distribution network; so that the water operators may follow the right procedures and document in their record. For the implementation and monitoring of the recommended control measures and SOPs, a Technical

Working Committee (TWC) is also formed and notified by the Secretary Local Government, Housing and Town Planning Government of Sindh.

To address above mentioned deficiencies and to improve access to safely managed water for residents, it is realized to develop Water Safety Plan (WSP) that includes clear road map, plan of action, standard operating procedures, check and balance for the improvement of water quality and adequate water supply at the doorstep of consumers.

# CHAPTER 1. INTRODUCTION

## 1.1 Background

The water is taken from river Indus and canals for storage and sedimentation. The water then carried by gravity flow for filtration and chlorination. After necessary water treatment, the water supply provided to the different parts of the town.

The water is provided to inhabitants. The population of is expected to grow at the rate of 2 percent annually.

## 1.2 Water Safety Plan

The water safety plan for 5 Municipal Committees (MCs) i.e **Mehar, Khairpur Nathan Shah, Johi, Kambar and Shahdadkot** has been prepared with support of review of **secondary data** including various reports, documents, plans, policies, protocols and standard manuals, water commission findings & recommendations and **primary data** including consultations with community representatives as well as technical team of all 5 MCs, meetings, visits of sites from lagoons to consumer level.

Water Safety Plan (WSP) is the most effective means of consistently ensuring the safety of drinking water supply through comprehensive risk assessment and risk management approach that encompasses all steps in the water supply system from catchment to the consumer. WSP addresses the overall issues of complete program wherein delivery of water from source to end users mapped through different means to assess the risk of water contamination at various levels. The objectives of a Water Safety Plan are to ensure safe drinking-water through best water supply practices to:

a) Prevent contamination of water at source;
b) Treat the water to reduce or remove contamination that could be present to the extent necessary to meet the water quality targets;
c) Prevent re-contamination during storage, distribution and handling of drinking water.

After detailed analysis of the hazards, risks and responses of community and the water operators, the Water Safety Plan was developed to meet the objectives of water safety. The framing and implementation of WSP will help to achieve better quality of water in sustainable manner by optimization of the possibilities of any risk of contamination. The WSP will lead to enormous health benefits because safe drinking water ensures reduction in mortality. WSP is prepared based on preventive risk management to effectively monitor and manage potential water contamination.

## 1.3 Water Safety Plan Approach

The preventive management framework provides recommendations on development of Water Safety Plan focusing on organized water supplies. This framework includes SOPs that can be implemented by the agency responsible for supplying drinking water with safety. This document can also assist supervisory and supporting agencies including regulators and auditors.

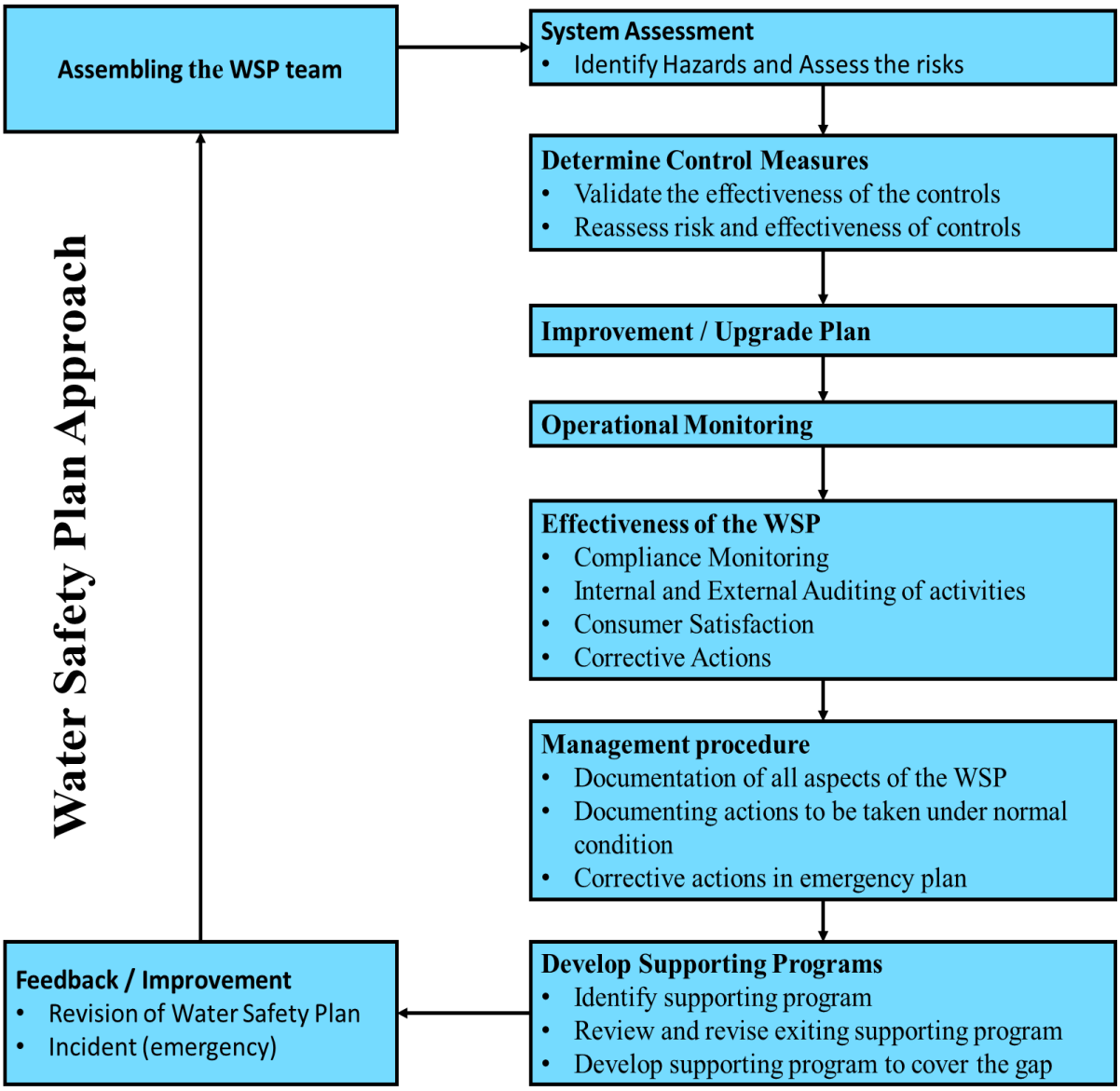



**Figure 1: Water Safety Plan Approach**[2]

[2] Adopted from Water Safety Plan Manual, World Health Organization & International Water 2009.

### 1.3.1 Water Quality of River Indus

The quality of raw water through water intake works can be examined from the daily records of chemical properties tested at Laboratory setup at filter plants. At filter plants, analysis of raw water content of Total Dissolved Solids (TDS), chlorides, hardness, alkalinity, pH value and turbidity tests are performed daily; whereas sulphate and nitrate tests are carried periodically. From the examination results, average values of turbidity, TDS, sulphate and chlorides can be calculated monthly and characterized in terms of wet and dry seasons with variation on yearly basis.

The quality of the river water is fairly stable and chemical constituents are up to desirable levels for drinking water. However, the silt content become very high during the flood season and creates problems for the raw water transmission and treatment. These problems are overcome with operation of pre-settlement lagoons.

### 1.3.2 Water Protection

Since the source is not adequately protected against pollution by natural means, the supply should be adequately protected by treatment. The major danger associated with drinking water is the possibility of its contamination by sewerage containing human excretes. Such sewerage may contain pathogenic bacteria capable of spreading typhoid, fever, cholera or other enteric diseases. The organisms that have been commonly employed as indicators of faecal pollution are e-coli and the coliform group. Therefore, supply mains are to be relocated sufficiently away from sewerage lines and open drains. Whereas plumbing works of houses and water connections should be of standard quality and undertaken through licensed plumbers under the supervision of experienced plumbing expert/ engineer.

### 1.3.3 Water Treatment

Treatment plant is based on rapid sand filtration process. With addition and augmentation of clarifier.

### 1.3.4 Distribution System

The distribution network contains water supply lines and pumping stations serving present population. Settled raw water is pumped into the clarifiers at filter plants through pumping mains. The mains are of ductile iron pipes, GRP and steel pipes, whereas AC, PRCC, HDPE and MS pipes are used as pressure pipes with protective coating of bitumen, mortar lining on outside and cement concrete lining inside.

After filtration, the treated water conveyed to major pumping stations, thereafter other pumping stations included in the system are serving mainly as intermediate and booster stations. The water is pumped either directly into the distribution mains or goes to HSRs or LSRs; the later combined with pumping stations.

## 1.4 Sewerage System

The following three types of sewerage system exist:

- Open drains / Nallahs.
- Underground sewers.
- Septic tank / Soaking pits.

Open drains and gutters are of lined concrete or brick masonry. Street crossings are made of rolled steel channel and spot-welded. These small surface sewers discharge into main open sewers/ nallahs and irrigation canals. The sewerage is designed on gravity system, draining to pumping stations which pump the flow to disposal points.

The most unsuitable and unhealthy locations are unauthorized Kattchi Abadis and informal settlements on low-lying areas with pools of sewage. The sewerage from developed localities pumped directly into sewerage treatment plants.

The generated quantity of sewage is about 85% of total water supplies. The un-acceptable quality effluent creates pollution for the communities and farm lands

## 1.5 Solid Waste and Impact on Water Supply Network

In urban areas, the solid waste is the major cause of pollution. Large quantities of municipal waste, debris and hospital waste are collected and dumped near water bodies. The solid waste management system is poor which is not only causing insanitation and pollution but also spread several diseases.

General waste is of mixed type and contains household waste, street sweeps, animal carcasses waste from slaughter houses and food markets etc. whereas hazards waste mainly come from hospitals and clinics which is categorized as special waste. The generated quantity of solid waste is about 0.54 kg/capita/day which is around 1000 ton/day (0.8 million tons / year).

The UCs under surveillance of MCs collect 51% and rest goes to the environment, providing breeding places for diseases vectors and environmental hazard components. The collected waste goes to disposal sites without any treatment in an unplanned manner. The community throws domestic waste and garbage normally outside the houses in open sewage drains and streets instead of allocated places such as Kachra Kundi (dustbins) etc. This style of waste disposal has caused sewerage / blockage and over flowing of wastewater on streets mixing with buried old water lines through leaked joints and poor water connections. Therefore, great health risk is associated due to the growth of disease vectors in such areas that may lead to epidemic burst of water borne diseases in the city.

## 1.6 Pumping Stations and Structures

There are pumping stations and boosters at different locations.

The realistic budgets with increase in water connections and enhancement of water rates is necessary; keeping in view the capacity of public to pay for the utility willingly.

This is only possible when baseline survey of service connections conducted periodically for the recovery of water charges. Moreover, commercial and industrials consumers should be given meters and charged money on monthly basis for increasing revenue.

# CHAPTER 2. WATER SAFETY PLAN TEAM

Water Safety Plan team includes qualified technical experts having responsibility and understand whole water supply process from catchment, treatment and distribution to the end users and well aware of identifying hazards that can benefit water supply system. The team will develop, implement and maintain WSP as fundamental part of their duty. All team members should play their effective role in development and effective running of the plan. The fundamental task for the team will be to set out methodology for WSP approach.

## 2.1 Engage Senior Management

Senior management support for successful implementation of WSP is needed to support in work process and to ensure availability of sufficient financial resources and endorse proper flow of water safety plan to provide quality water.

## 2.2 Identify Required Expertise and Size of the Team

Authoritative technical operational staff will be needed for successful running of the plan who will facilitate in implementation process of WSP through their skills in identifying hazards and facilitating in appropriate measure to control those risks.

## 2.3 Appoint Team Leader

A team leader will be needed for effective and continuous operation of the WSP who will manage all activities regarding implementation of plan and provide alternative support in case of any gap occurred in implementation process.

## 2.4 Proposed WSP Team

The technical expertise is needed to implement this Water Safety Plan; assemble a team of experts in water quality monitoring, coming from operations and technical services groups. These individuals as given in below table possess vast experience in understanding the quality of raw water, its treatment and distribution.

**Table 1: Proposed WSP Implementation and Monitoring Team**

| Sr. | Job Title | Work Team | Expertise | Roles and responsibility |
|---|---|---|---|---|
| **1** | Senior Manager / Team Leader | Water Quality Planning | Water Quality Engineering | • Water quality planning and management;<br>• Develop and implement improvement/ up gradation plan;<br>• Develop support program;<br>• Determine and validate control measures, re-assess and prioritize the risks. |
| **2** | Water Supply Operators (AEN WPD) | Major Filter Plants / Pumping Stations | Treatment Plant Operation | • Operate major filter plants;<br>• Operate major pumping stations;<br>• Ensure water safety at key steps. |
| **3** | Manager Water Treatment (AEN WTP) | Treatment Systems | Treatment Plant Asset Management | • Manage water treatment systems;<br>• Check control measures;<br>• Perform routine monitoring;<br>• Protect water safety at key components. |
| **4** | Process Engineer (AEN) | Storage & Operations | Water Supply Engineering | • Manage storage & operations;<br>• Ensure water service without break;<br>• Additional control measures to prevent water safety hazards. |
| **5** | Chief Chemist (Lab In-charge) | Water Quality Control | Microbiology | • Water testing and sampling Control water quality. |
| **6** | Intake / Source Supervisor (AEN) | Operations | Catchment & Intake Operations | • Coordinate with the source regulators and environmental agency;<br>• Monitor water flows and impurities;<br>• Check un-authorize encroachments and activities. |
| **7** | Engineer Water Network (AEN Maintenance) | Distribution Network | Distribution & Quality Control | • Control distribution system;<br>• Control un-authorize water connection and pumping;<br>• Maintain pressure in water network system. |
| **8** | Plumbing Engineer (AEN) | Household Plumbing Works | Plumbing Works Expert | • Check plumbing works/ fitting, installations;<br>• Provide water connections;<br>• Inspect hygienic HH storage/ tanks. |
| **9** | Manager Taxation & Billing<br>Fin & Tax Officer) | Billing & Tax Collection | Taxation and Revenue | • Billing and recovery;<br>• Redress customer complaints;<br>• Review water tariff;<br>• Organize community awareness program. |

## 2.5 Manage Financial & Resource Support

The support of senior management is important for the implementation process of Water Safety Plan. It is necessary to acquire assistance for changes in working practices, ensure sufficient financial resources and actively promote water safety as a goal of the organization. The senior management's commitment may be achieved by providing clear and coherent opinion about why and how the adoption of a WSP is important and advantageous to the organization.

- **Managers;**
- **Engineers (Design & Planning);**
- **Water quality control staff (environmental engineer, microbiologists & chemists);**
- **Operators, Supervisors, Inspectors.**

# CHAPTER 3. SYSTEM ASSESSMENT

## 3.1 Infrastructure Condition Assessment (Structures, Equipment and Machinery)

The infrastructure assessment included civil engineering structural assessment, mechanical and electrical installation assessment. Locations were surveyed.

1. Except for a few recent structures, most of the structures have been built a long time ago as such they need rehabilitation.
2. There is no record of "As-built" drawings making it difficult to trace various services/ facilities built into the structure;
3. There is no "log" showing the maintenance schedule of these structures, some seem not to have been even painted eight to ten years back;
4. Some of the facilities have been encroached upon by "land grabbers" and the premises should be immediately got vacated from these grabbers;
5. In some cases, the sites are being used as garbage dumps that need to be cleared immediately;
6. The lagoons must be cordoned off with fencing to avoid animals (and unauthorized persons) entering into the water and contaminating it.

### 3.1.1 Findings of the Assessment

Most of the structures have been constructed a long time back. Being built such a long time back when technology was not so developed and due to dearth of maintenance, some of those have outlived their lives. Following structures are a few to be named:

## 3.2 Complaint Management System

A number publicized among consumers to register their complaints. However, the Complaint Management System is not functional since long. The consumers also reported unavailability of any complaint registration mechanism. Therefore, they face serious problems for redressal of their grievances and informed that this was one of the reason of their dissatisfaction over services. Furthermore, the random household survey conducted, shows that 80% users do not know about complaint management system.

## 3.3 Recommendations for System Assessment in 5 MCs

The structures are damaged and deteriorated and need repairing. Also in some of the premises there are spaces available for future extension: However the following recommendations are for all 5 MCs as per the standards / protocols of WHO for water safety plan of any type of entity. Each MC can adopt these recommendations as per their applicability.

- Prepare a plan and submit to the Government for all the old structures and pipes to be repaired/ rehabilitated.
- A protocol of maintenance must be prepared and implemented.
- Civil Supervisory staff be appointed with immediate effect to look after and maintain the structures.
- Encroachments made within premises by land grabbers must be immediately got vacated

# CHAPTER 4. IDENTIFICATION OF HAZARDS AND RISK

## 4.1 Identification of Hazards and Risks

A physical on-site general hazard and risk assessment was conducted from 72 random locations comprising intake pumping stations, lagoons, treatment plants and pumping stations and booster pumps across the town. A general qualitative condition assessment conducted by an environmental expert followed by detailed questionnaire surveys each from different locations. The questionnaires were designed according to the type of locations e.g. intake pumping station, lagoon, etc. where various things considered in the assessment. For instance, the presence or access of animals to the source of the water, disposal of solid waste and wastewater in the upstream of the source water, proper chemical dosage of the water in the treatment plant checked.

Detailed hazards and risk profiles with their impacts and control measures shown in Tables below at water source, lagoon, water treatment plants and distribution system. No monitoring of the water quality along the distribution system got the highest rating of 100 and categorized as high risk. Solid waste dumping in water sources, access of animals to lagoons, improper chlorination, mixing of treated water with untreated water, mixing of water with wastewater in the distribution lines, untrained personnel, uncovered storage tanks at pumping stations and toxic pipe materials are a few of the categories rated as high risks.

The risk estimation for each identified hazards were performed by using a semi-quantitative risk matrix. Each hazardous event was given a score each for likelihood and severity or consequence in the range from 0.1 to 01 and 01 to 100 respectively. The hazardous events were rated based on the physical observations during the onsite condition assessment. The definitions for each score are shown in Tables 7 and 8. The risk ratings, having values from 0 to 100 were calculated by multiplying the likelihood by the severity. A risk having a rating from 0 to 10 was classified as a low risk while those having scores from 11 to 56 and 57 to 100 were classified as medium and high risks respectively.

**Table 2: Description and Ratings Associated with the Likelihood of Hazards**

| Likelihood | Rating | Frequency |
|---|---|---|
| Almost certain | 1.0 | Once per day/present at almost all locations |
| Likely | 0.8 | Once per week/present at 80% of the locations |
| Moderately likely | 0.5 | Once per month/present at 50% of the locations |
| Unlikely | 0.2 | Once per year/present at 20% of the locations |
| Rarely | 0.1 | Once in five years/present at 10% of the locations |

**Table 3: Description and Ratings Associated with the Consequences of Hazards**

| Consequence | Rating | Severity |
|---|---|---|
| Catastrophic | 100 | Potentially lethal to all people; death expected from exposure |
| Major | 70 | Potentially harmful to all; significant illness from exposure |
| Moderate | 20 | Potentially harmful to vulnerable groups following chronic exposure; large aesthetic impact |
| Minor | 2 | Small aesthetic impact |
| Insignificant | 1 | No impact or not detectable |

**Table 4: Observed Hazards at Water Sources along with their Risk Ratings, Risk Profiles, Impacts and Control Measures**

| Location | Hazard | Likelihood (0.1-1) | Severity (1-100) | Risk Rating | Risk Profile | Impacts | Control measures |
|---|---|---|---|---|---|---|---|
| Source | Access of animals near the intake points | 0.8 | 20 | 16 | Medium | Microbial contamination; animal feces; insects; vermin | **High:**<br>• Solid waste dumping and waste water disposal should not be allowed in the water sources.<br>**Medium:**<br>• Water quality at the source should be checked regularly to remain aware of any pollutant contaminating the water source.<br>• Water quantity supplied should be recorded.<br>• Logs of system operated on electricity from grid and standby generator should be maintained.<br>• Screens should be installed at the suction points of the pumps.<br>• There should be either no access to people and animals, or the activities limited one to two |
| | Bathing and washing near the intake points | 0.8 | 20 | 16 | Medium | Increased nutrient concentration; microbial contamination | |
| | Solid waste dumping in water sources | 0.8 | 100 | 80 | High | Chemical and hazardous contamination; microbial contamination; turbidity; spread of infectious diseases; waterborne diseases; decreased DO; aquatic life destruction | |
| | Wastewater disposal in water sources | 0.8 | 70 | 56 | Medium | Microbial contamination; turbidity; spread of infectious diseases; waterborne diseases; decreased DO; aquatic life destruction; increased nutrient concentration | |

| Location | Hazard | Likelihood (0.1-1) | Severity (1-100) | Risk Rating | Risk Profile | Impacts | Control measures |
|---|---|---|---|---|---|---|---|
| | torm water runoff in water sources | 0.2 | 20 | 4 | Low | Microbial contamination; turbidity; different kinds of waste ending up in the source water | kilometers upstream of the water sources.<br>• No houses, hotels or animal barns should be allowed on or around the embankments of the river and/ or canal.<br><br>**Low:**<br>• Water level at upstream. |
| | Litter and dust particles from metaled roads into water sources | 0.5 | 20 | 10 | Low | Microbial contamination; turbidity | |
| | Encroachments on river/canal banks | 0.8 | 70 | 56 | Medium | Solid waste and wastewater disposal in water sources | |

**Table 5: Observed Hazards at Lagoons along with their Risk Ratings, Risk Profiles, Impacts and Control Measures**

| Location | Hazard | Likelihood | Severity | Risk Rating | Risk Profile | Impacts | Control Measures |
|---|---|---|---|---|---|---|---|
| Lagoon | Access of animals to lagoons | 1 | 70 | 70 | High | Microbial contamination; animal feces; insects; vermin | **High:**<br>• Water quality at the inlet and outlet of lagoons should be assessed.<br>• Inspect the lagoon embankments especially during the rainy season.<br>• Maintaining proper operating para meters.<br>• The outlet chambers of the lagoons supplying water to treatment plants should be covered with easy-to-remove lids.<br>• No houses or animal barns should be allowed on or around the embankments of the lagoons.<br>• Solid waste dumping and wastewater disposal in the lagoons should not be allowed.<br>• Desilting and de-weeding of lagoons. |
| | Access of unauthorized personnel to lagoons | 1 | 20 | 20 | Medium | Security risk | |
| | Swimming/bathing in lagoons | 1 | 20 | 20 | Medium | Microbial contamination | |
| | Washing clothes in lagoons | 0.8 | 20 | 16 | Medium | Nutrient contamination; turbidity; microbial contamination | |
| | Insufficient hydraulic retention time in lagoons | 1 | 20 | 20 | Medium | Inefficient particle settling; higher particle load on downstream processes | |
| | Weed growth | 1 | 20 | 20 | Medium | Decreased DO; may attract insects; microbial contamination; release of toxins | |
| | Silt deposits | 1 | 20 | 20 | Medium | Reduced detention time; short circuiting of flow; reduced reservoir volume | |

| Location | Hazard | Likelihood | Severity | Risk Rating | Risk Profile | Impacts | Control Measures |
|---|---|---|---|---|---|---|---|
| | Bypassing prior lagoons to fill successive lagoons | 0.8 | 70 | 56 | Medium | Reduced detention time; ineffective particle settling | **Medium:**<br>• Unauthorized personnel should not be given the access to the lagoons.<br>• Swimming and washing clothes in the lagoons should not be allowed.<br>• Inspecting and recording the lagoons for silt and weed growth.<br>• Screens should be installed before the suction points of the pumps.<br>• Collecting percolated/seepage water for reuse.<br><br>**Low:**<br>- |
| | Absence of screens | 1 | 20 | 20 | Medium | Potential damage to WTP machinery | |
| | Extraction of water from non-terminal lagoons | 0.8 | 70 | 56 | Medium | Reduced detention time; ineffective particle settling | |
| | Shortage of chemicals (alum and hypochlorite) | 0.5 | 70 | 35 | Medium | Ineffective treatment; high turbidity; high microbial load | |
| | Lack of technical knowledge of the staff to maintain optimum operating conditions at lagoons | 0.8 | 70 | 56 | Medium | Non-optimal operations | |

**Table 6: Observed Hazards at Water Treatment Plants along with their Risk Ratings, Risk Profiles, Impacts and Control Measures**

| Location | Hazard | Likelihood | Severity | Risk Rating | Risk Profile | Impacts | Control Measures |
|---|---|---|---|---|---|---|---|
| Treatment Plant | Access of animals | 0.2 | 100 | 20 | Medium | Microbial contamination; animal feces; insects; vermin | **High:**<br>• Dosing of coagulants and disinfectants.<br>• Water quality assessment.<br>• Filter media.<br>• Mixing of untreated raw water with treated product water.<br>• Operating parameters.<br>• Water storage tanks.<br>• Staff-training and recruitment.<br>• Construction of new treatment plants and expansion of the existing facilities.<br><br>**Medium:**<br>• Stocking of chemicals.<br>• Application points of chemicals.<br>• Alum tanks.<br>• Installation of flow meters.<br><br>**Low:**<br>- |
| | Insufficient alum dosage | 0.5 | 20 | 10 | Low | Turbid water; inefficient particle settling; high particle load prior to sedimentation | |
| | Insufficient residence time in sedimentation tanks | 0.5 | 70 | 35 | Medium | Turbid water; inefficient particle settling; high particle and microbial load prior to filtration and disinfection | |
| | Insufficient chlorination | 1 | 70 | 70 | High | Active microorganisms | |
| | Fixed concentration of chlorine dosing | 0.2 | 70 | 14 | Medium | Higher or lower than required chlorine concentration | |
| | Discontinuous chlorination | 0.5 | 70 | 35 | Medium | Entry of microbes in the distribution system | |
| | Application of chlorine to untreated or partially treated | 0.8 | 20 | 16 | Medium | Carcinogenic disinfection by-products; higher dose of | |

| Location | Hazard | Likelihood | Severity | Risk Rating | Risk Profile | Impacts | Control Measures |
|---|---|---|---|---|---|---|---|
| | water (in case dissolved organic carbon is present in water) | | | | | disinfectant will be consumed | |
| | Water distributed without disinfection | 0.8 | 70 | 56 | Medium | Presence of microorganisms; turbid; potentially disease causing | |
| | Mixing of treated water with untreated water | 1 | 70 | 70 | High | Presence of microorganisms; turbid; potentially disease causing | |
| | Uncovered storage tanks at treatment plants | 0.5 | 70 | 35 | Medium | Access to animals; ingress of contaminants and dirt | |
| | Water quality assessment of low number of parameters | 0.8 | 70 | 56 | Medium | Incomplete picture of the water quality | |
| | Non-standard methods for water quality assessment | 0.8 | 20 | 16 | Medium | Unreliable water quality assessment | |

| Location | Hazard | Likelihood | Severity | Risk Rating | Risk Profile | Impacts | Control Measures |
|---|---|---|---|---|---|---|---|
| | Incorrect methods for water quality assessment | 0.5 | 70 | 35 | Medium | Incorrect water quality assessment | |
| | Lack/unavailability of instruments/ equipment/reagents in water quality laboratories | 0.5 | 70 | 35 | Medium | Inability to detect contaminants and analyze specific water quality parameters | |
| | Lack of trained personnel | 1 | 70 | 70 | High | Non-optimal functioning of the WTP | |
| | Non-functional water quality laboratories | 0.5 | 70 | 35 | Medium | Unknown water quality; potentially dangerous | |
| | Non-functional WTPs | 0.2 | 70 | 14 | Medium | Raw water to end-users | |
| | Not-to-be-used but filled chlorine gas cylinders unattended at WTPs | 0.2 | 100 | 20 | Medium | Fatal if leaked | |

**Table 7: Observed Hazards at the Distribution System along with their Risk Ratings, Risk Profiles, Impacts and Control Measures**

| Location | Hazard | Likelihood | Severity | Risk Rating | Risk Profile | Impacts | Control Measures |
|---|---|---|---|---|---|---|---|
| Distribution System | Flood-prone pumping stations and booster pumps | 0.2 | 100 | 20 | Medium | System failure during rains; electrocution | **High:**<br>• Water quality assessment along the distribution system.<br>• Maintain a clean and hygienic environment in and around the pumping stations.<br>• Providing cemented foundation to booster pumps.<br>• Cleaning of water storage tanks.<br>• Information management system.<br>• Right of way for transmission mains.<br>• All illegal and informal connections should be disconnected along with abandoned and old connections.<br>• Only approved connections should be allowed. |
| | Lack of foundation for motors/pumps | 0.2 | 20 | 4 | Low | Unbalanced equipment; soil erosion | |
| | Improper and temporary shades on motors | 0.8 | 20 | 16 | Medium | Open to direct sunlight and precipitation; prone to get stolen/vandalism | |
| | Mixing of water with wastewater in the distribution lines | 1 | 70 | 70 | High | Microbial contamination; waterborne diseases | |
| | Uncovered storage tanks at pumping stations | 1 | 70 | 70 | High | Access to animals; ingress of contaminants and dirt | |
| | Pipe corrosion | 0.8 | 70 | 56 | Medium | Release of toxic materials in water; metal contamination; reservoir for microbes; accelerated growth of biofilm; micro pockets for nutrient and debris capture | |

| Location | Hazard | Likelihood | Severity | Risk Rating | Risk Profile | Impacts | Control Measures |
|---|---|---|---|---|---|---|---|
| | Harmful/toxic pipe materials | 0.8 | 100 | 80 | High | Release of toxic materials in water; chronic exposure may lead to potential diseases depending on the material | • Standard operating procedures (SOPs) for developmental works.<br>• Chlorine boosters.<br>• Research and development team.<br>• The water-supply lines should be placed at a safe distance from the sewerage lines.<br>• Old and leaky pipes should be replaced by new pipes.<br>• Toxic pipe materials.<br>• Construction of overhead tanks.<br><br>**<u>Medium:</u>**<br>• Inspection of pressure chambers.<br>• Avoid negative pressure in transmission mains.<br>• SOPs for pipe materials for mains, service and consumer lines. |
| | Flooded water distribution pipes | 0.2 | 70 | 14 | Medium | Ingress of raw/sewage water through holes or leaks; ingress of contaminants | |
| | Water distribution lines inundated in sewers | 0.2 | 100 | 20 | Low | Ingress of sewage water through holes or leaks; ingress of contaminants; microbial contamination | |
| | Damaged pipelines | 0.5 | 70 | 35 | Medium | Ingress of raw/sewage water through holes or leaks; ingress of contaminants; turbidity | |
| | No cleaning of the mains/pipes | 1 | 70 | 70 | High | Biofilm formation; old age water at dead ends | |
| | No monitoring of the water quality along the distribution system | 1 | 100 | 100 | High | Water contamination along the distribution system cannot be detected | |
| | No chlorine boosters along the | 1 | 70 | 70 | High | Re-growth/reactivation of microbes; zero/reduced | |

| Location | Hazard | Likelihood | Severity | Risk Rating | Risk Profile | Impacts | Control Measures |
|---|---|---|---|---|---|---|---|
| | distribution system | | | | | residual disinfectant concentration in water away from the WTPs | • Cleaning of the pipelines.<br>• Installation of flow meters. |
| | No SOPs for developmental works | 1 | 70 | 70 | High | Higher probability of pipelines getting damaged resulting in decrease in water quality and quantity | **Low:**<br>- |
| | Illegal and informal water connections | 0.8 | 70 | 56 | Medium | Impacts on water quantity and quality; higher load on water resources; unaccounted water | |
| | Abandoned water connections | 0.8 | 70 | 56 | Medium | Ingress/suction of raw/sewage water from the abandoned pipes | |
| | Lack of provisions for alternate water-supply | 0.8 | 20 | 16 | Medium | Inability to provide water during default system failure | |
| | Leakages | 0.8 | 70 | 56 | Medium | Water loss; unaccounted water; ingress of contaminants when mains do not have water | |
| | Pressurized motor pumps in households | 1 | 70 | 70 | High | Inequitable distribution of water; ingress of contaminants when mains do not have water | |

## 4.2 Water Sampling and Analysis

Different water testing laboratory reports were reviewed which reveal that most of the water samples collected between main sources to consumer level are exceeding the maximum allowable limit for turbidity. The bacterial contamination was also high rendering 72.92-94.71% of samples unfit for drinking. Arsenic exceeded in none of the samples while TDS was present in higher than desired quantity in only one sample. Analysis showed that water was not only not being effectively treated but the water quality deteriorated further after entering the distribution system.

## 4.3 Identification of Hazards & Risks Assessment at Community Level

The household survey was conducted at community level. During survey 300 respondents were interviewed from different entities. The following tables depict the responses from water users at community level on water supply risks, hazards and management issues.

**Table 8: Water users at community level on water supply risks, hazards and management issues**.

| Type of Entity | Respondents | |
|---|---|---|
| | Number | % |
| Houses | 226 | 75 |
| Schools | 20 | 7 |
| Hospitals | 9 | 3 |
| Hotel//Restaurants | 41 | 14 |
| Animal Farms | 4 | 1 |
| **Total** | **300** | **100** |

Table No 8 shows that out of 300 respondents, 75% were from Houses, 14% from Hotels/Restaurants, 7% from Schools, 3% and 1% from Hospitals and Animal Farms respectively. Respondents were selected from different entities to represent overall situation.

**Table 9: Drinking Water from User Main Source is safe and Drinkable**

| Safe for Drinking | Respondents | |
|---|---|---|
| | Number | % |
| Yes | 48 | 16 |
| No | 211 | 70 |
| Don't know | 41 | 14 |
| **Total** | **300** | **100** |

70% respondents said that their drinking water from water supply is not safe to drink, 16% users feel it is safe and drinkable while 14% do not know whether it is safe or not safe to drink.

**Table 10: Water Contain Smell**

| Water contain smell | Respondents | |
|---|---|---|
| | Number | % |
| Yes | 58 | 19 |
| No | 242 | 81 |
| **Total** | **300** | **100** |

81% respondents had smell in their drinking water whereas other of users did not feel any smell.

**Table 11: Drinking Water has Different Taste**

| Different Taste | Respondents | |
|---|---|---|
| | Number | % |
| Yes | 166 | 55 |
| No | 134 | 45 |
| **Total** | **300** | **100** |

55% of users informed that they feel some taste in drinking water while 45% did not feel any taste in their drinking water.

**Table 12: Drinking Water: Clear in Color**

| Clear Color | Respondents | |
|---|---|---|
| | Number | % |
| Yes | 22 | 7 |
| No | 278 | 93 |
| **Total** | **300** | **100** |

93% users reported that their drinking water was not clear in color/ dusty and only 7% informed that they receive clear in color drinking water.

**Table 13: Drinking Water Contain Materials**

| Contain materials | Respondents | |
|---|---|---|
| | Number | % |
| Yes | 179 | 60 |
| No | 121 | 40 |
| **Total** | **300** | **100** |

60% users observed some tiny material in drinking water whereas, 40% users did not found material in drinking water.

**Table 14: Observed Any Severe Case Nearby Due to Bad Quality of Drinking Water During Past 3 Months**

| Severe case | Respondents | |
|---|---|---|
| | Number | % |
| Yes | 162 | 54 |
| No | 138 | 46 |
| **Total** | **300** | **100** |

54% respondents observed sever case nearby their entity; while 46% did not report any sever case due to bad quality of drinking water during past three months.

# CHAPTER 5. VALIDATION OF CONTROL MEASURES & PRIORITIZATION OF RISKS

## 5.1 Identification of controls

### 5.1.1 Control Measures at Sources

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| High | Intermediate to long-term | Solid waste dumping and wastewater disposal should not be allowed in the water sources. | • Regular and random patrolling by security guards along the water sources near the intake pumping stations.<br>• The patrolling personnel should come under the ambit of the team formed as in the 1st control measure in the medium category of the controls at water source.<br>• The sanitation and drainage department of municipal authorities responsible for solid waste management should be brought on board.<br>• Violators should be penalized. | • Onsite surveys and visits<br>• Water quality monitoring<br>• Microbiological tests (fecal contamination analysis) |
| | Intermediate to long-term | A new pipeline should be installed for Treatment Plant. | • Currently, the treatment plant is supplied water from the river water. Apart from the monsoon season, water flows downstream extremely low. Moreover, wastewater is also discharged in the Indus. Consequently, the Treatment Plant gets wastewater rather than freshwater as a raw water source. | • Physical existence of a new pipeline. |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| **Medium** | Continuous; requires immediate implementation | Water quality at the source should be checked regularly to remain aware of any pollutant contaminating the water source. | • Water quality assessment of the source should be carried out daily or on alternate day to remain aware of the varying water quality and flow characteristics. This will help in modifying the operating parameters of the treatment processes to achieve the water quality.<br>• The comparison of the water quality at the start and at the end of the water channel may also help in locating the contamination source.<br>• The standard methods for the examination of drinking water should be used in the water quality assessment.<br>• The personnel collecting and analyzing the samples should be trained and qualified in the entrusted responsibility.<br>• A few parameters need to be analyzed on-site, while for others, the samples need to be transported according to the standard methods to a laboratory located on the treatment plant premises.<br>• A sampling program should be devised for the frequency of sampling and the parameters to be analyzed. | • Water quality analysis by a third-party |
| | Immediate | Water quantity supplied should be recorded. | • A record for the quantity of water supplied should be kept by maintaining the logs.<br>• Flow meters should be installed to measure the water quantity. | • Logbook |

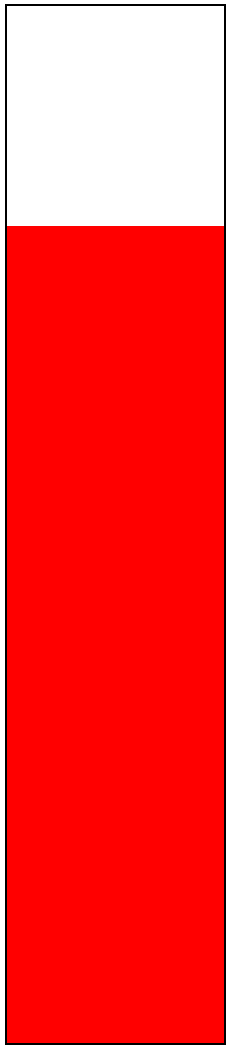
| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Immediate | Logs of system operated on electricity from grid and standby generator should be maintained. | • A logbook should be maintained for the number of hours the system runs on the electricity from the grid and from the standby system, i.e. a generator. | • Logbook<br>• Diesel consumption |
| | Intermediate | Screens should be installed at the suction points of the pumps. | • Coarse screens should be installed at the suction points of the pumps to screen out any coarse materials from going into the treatment plant machinery or lagoons.<br>• Screens should be designed keeping in view of the expertise of the personnel at the treatment plant.<br>• Screens should be cleaned after the clogging reaches a predefined threshold.<br>• Screens should be inspected daily for large objects stuck between the bars. | • Onsite physical inspections<br>• Head loss at screens<br>• Quantity of screenings generated<br>• Screen-cleaning frequency<br>• Frequency of the breakdown of pumps and other machinery due to coarse materials in the water |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Intermediate | There should be either no access to people and animals, or the activities limited one to two kilometers upstream of the water sources. | • Collaboration and coordination between MCs and the legal body that is responsible for and has custody of the water sources, i.e. canals and river.<br>• A pre-decided distance upstream of the intake should be regularized with the help of that legal team.<br>• Human and animal activities should be disallowed according to the risks associated with the respective activities.<br>• A representative or a group of representatives from MCs should be selected to coordinate with the custodian bodies of the water sources.<br>• Regular water quality assessments and source tracking should be conducted to evaluate the performance of the combined team. This team should be answerable to an official of the Sindh Environment Protection Agency (SEPA).<br>• Alternatively, an official of the SEPA could also be made a member of this body.<br>• Separate areas can be designed to provide drinking water to animals from the sources without compromising on the water quality.<br>• The slope of the area around the sources can be designed so that runoff from the surroundings does not end up in the sources.<br>• Likewise, designated areas to wash clothes for nearby settlements may be provided. | • Onsite visits<br>• Existence of fence along the water sources 1-2 km upstream of the intake point<br>• Meetings of the responsible agencies and committees<br>• Water quality analysis<br>• Physical existence of engineering interventions, e.g. clothes washing area, separate area for animals to drink water, etc. |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Long-term | No houses, hotels or animal barns should be allowed on or around the embankments of the river and/or canals. | • All encroachments should be removed that are built on or around the embankments of the river or canals before consulting with the provincial and local governments.<br>• Due procedure should be followed according to the law so none of the parties suffer.<br>• The Sindh Building Control Authority and the nearby communities should be taken onboard.<br>• The government should provide alternate housing site to those who would lose their homes. | • Onsite physical inspections |
| Low | Immediate | Water level at upstream | • Gauges should be installed to check the water level in the sources upstream from the intake points. | • Flow data<br>• Onsite physical inspection |

### 5.1.2 Control Measures at Lagoons

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| High | Immediate | Water quality at the inlet and outlet of lagoons should be assessed. | • The SOPs for the water quality assessment from the lagoons are the same as those from the source.<br>• The water quality at the inlet and outlet of lagoons should be checked regularly to measure the sedimentation efficiency in the lagoons.<br>• The quality assessment of the water from the outlet chamber should also be carried out. | • Water quality analysis reports<br>• Water quality analysis by a third-party |
| | Immediate | Inspecting the lagoon embankments especially during the rainy season | • The embankments of lagoons should be inspected after a fixed time interval, especially during and after monsoons.<br>• Immediate actions should be taken in case signs of damage or potential breach are observed. | • Onsite physical inspections |
| | Immediate | Maintaining proper operating parameters | • The required hydraulic retention time must be achieved. Short-circuiting or bypassing the ponds will affect the downstream unit operations and processes. | • Turbidity analysis<br>• Hydraulic retention time |
| | Immediate | The outlet chambers of the lagoons supplying water to treatment plants should be covered with easy-to-remove lids. | • Provide lids | • Onsite physical inspection |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
|  | Immediate to Intermediate | No houses or animal barns should be allowed on or around the embankments of the lagoons. | • All encroachments should be removed that are built on or around the embankments of lagoons.<br>• The government should provide alternate housing to those who would lose their homes. | • Onsite physical inspections |
| | Long-term | Solid waste dumping and wastewater disposal in the lagoons should not be allowed. | • Regular and random patrolling by security guards on the premises of the lagoons.<br>• The patrolling personnel should come under the ambit of the team formed as in the 1st control measure in the medium category of the controls at water source.<br>• The sanitation and drainage department of municipal authorities responsible for solid waste management should be brought on board. | • Onsite surveys and visits<br>• Water quality monitoring<br>• Microbiological tests (fecal contamination analysis) |
| | Long-term | Desilting and de-weeding of lagoons | • Regular desilting programs to ensure proper functioning in terms of particle-settling and detention time, and to avoid the building-up of organic matter and bacterial growth.<br>• Regular de-weeding programs for lagoons are also vital for the proper functioning of the whole treatment process. | • Onsite physical inspections<br>• Lack of algal blooms<br>• Dissolved oxygen concentrations at different depths<br>• Turbidity analysis<br>• Hydraulic retention time<br>• Lesser load on downstream treatment processes |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| **Medium** | Immediate | Unauthorized personnel should not be given the access to the lagoons. | • Lagoons should be fenced to stop free access.<br>• Security guards should be engaged at lagoon location. | • Onsite physical inspection<br>• Water quality analysis |
| | Immediate | Swimming and washing clothes in the lagoons should not be allowed. | • No person or animal should be allowed to enter the lagoons.<br>• No access to public will result the end of activities such as solid waste dumping, wastewater disposal, swimming and washing of clothes. | • Onsite physical inspection<br>• Water quality analysis<br>• Nutrient concentration in water |
| | Immediate | Inspecting and recording the lagoons for silt and weed growth | • Lagoons should be inspected for the accumulation of silt and growth of weed. Silt deposit per unit time should be measured and recorded and used for future references. This will help in determining the time interval between two desilting events. | • Hydraulic retention time calculations and comparisons with the recorded data |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Immediate to Intermediate | Screens should be installed before the suction points of the pumps | • Screens should be installed at the suction points of the pumps to prevent coarse materials from going into the treatment plant machinery.<br>• Screens should be designed in accordance with the flow characteristics and horsepower of the suction pumps. | • Onsite physical inspections<br>• Head loss at screens<br>• Quantity of screenings generated<br>• Screen-cleaning frequency<br>• Frequency of the breakdown of pumps and other machinery due to coarse materials in the water |
| | Intermediate | Collecting percolated/seepage water for reuse | • French drains may be used to collect and reuse percolated water from lagoons. This water can be sent to the treatment plant as raw water. Comparatively, seepage water would be of better quality than the raw water in lagoons. | • Mass balance, i.e. flow measurement of water flowing in and out of lagoons and their comparison with the seepage water collected.<br>• Physical existence of the French drains |
| **Low** | - | - | - | - |

### 5.1.3 Control Measures at Treatment Plants

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| High | Continuous; Immediate | Dosing of coagulants and disinfectants | • Proper and continuous dosing of coagulants and disinfectants should be done.<br>• Laboratory tests should be run to obtain required chemical dosages to apply according to the raw water characteristics.<br>• Like at the sources and lagoons, water quality assessment should also be done at treatment plants. | • Water quality analysis, especially microbial count and turbidity |
| | Continuous; Immediate | Water quality assessment | • Samples should be collected and analyzed before and after each unit process so that the treatment efficiency of each unit process could be determined.<br>• Microbiological analysis should be conducted daily as most of the samples didn't meet the standard criteria for microbial presence. | • Water quality analysis reports<br>• Water quality analysis by a third-party |
| | Immediate | Filter media | • Regular backwash according to a predetermined head loss should be practiced.<br>• Filter media should be replaced once the filtration efficiency drops below a certain threshold even after backwash. | • Head loss<br>• Filtrate quality |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Immediate to Intermediate | Mixing of untreated raw water and treated product water | • The mixing of untreated and treated water should be stopped immediately and temporary arrangements should be made to meet the water demand until the current water treatment capacity is increased. | • Water quality analysis, especially turbidity and microbial presence<br>• Comparison of water quality after treatment and after the potential point of mixing |
| | Immediate to Intermediate | Operating parameters | • Different parameters of the treatment plants should be optimized.<br>• Overflow rates in clarifiers should be set to achieve the optimum treatment efficiency and quantity of water without compromising the quality of the water.<br>• Hydraulic retention times in clarifiers should be studied.<br>• An optimum filter backwash interval and frequency should also be determined. | • Overall treatment efficiency along with efficiency at each unit treatment process<br>• Hydraulic retention time in clarifiers<br>• Turbidity levels after sedimentation<br>• Head loss at filter beds<br>• Microbial count after disinfection<br>• Water quality analysis before and after treatment |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Intermediate | Water storage tanks | • Storage tanks at the treatment plants should be covered and cleaned regularly to maintain the water quality after treatment. | • Onsite physical inspection<br>• Comparison of the water quality of the treated water with the water from the storage tanks |
| | Intermediate to Long-term | Staff-training and recruitment | • The staff working at the treatment plants should be given trainings in addition to hiring experts / environmental specialists to manage the treatment units and processes. | • Yearly evaluation/exam |
| | Long-term | Construction of new treatment plants and expansion of the existing facilities | • New treatment plants should be constructed, and/or the existing ones be expanded to meet the growing needs of the city.<br>• Population growth along with the socioeconomic factors should be considered when predicting the future water demand. | • Physical existence of new plants and expansion of existing ones |
| **Medium** | Immediate | Stocking of chemicals | • Alum and chlorine should be stocked and stored in safe places at treatment facilities.<br>• Minimum storage capacity of 3 months for alum and chlorine should be available.<br>• Storing chlorine is potentially dangerous therefore standard health and safety practices should be followed. | • Onsite physical inspections |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Immediate | Application points of chemicals | • Chemical injected at the correct stage in treatment process to maximize the effectiveness of the desired goal and reduce the harmful effects. For instance, when chlorine is applied in the presence of suspended solids and/or organic matter in the water, chlorine forms DBPs that are carcinogenic in nature. To prevent the formation of DBPs, water should be treated as efficiently as possible before chlorine application and all colloidal and suspended particles should be removed. The effective removal of suspended solids will also reduce the microbial concentration by removing particle-associated bacteria. Hence, chlorine demand will also be reduced resulting in decreasing the operating costs. If possible, disinfectants should be added between water leaving the storage tank and entering the distribution system to minimize the bacterial contamination acquired from the storage tank. | • Reduction in the quantity of a disinfectant used<br>• Reduction in the quantity of DBPs formed. |
| | Immediate | Alum tanks | • The tanks in which the alum is prepared should be covered with proper lids along with a regular cleaning program in place. | • Onsite physical inspections |
| | Immediate to Intermediate | Installation of flow meters | • Flow meters should be installed at the distribution point of the treated water to account for the water supplied. | • Water flow data<br>• Onsite physical inspections |

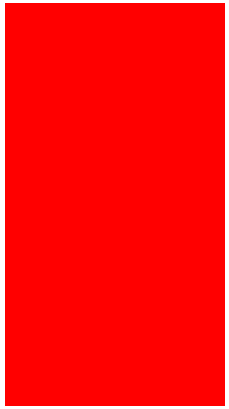
| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| Low | - | - | - | - |

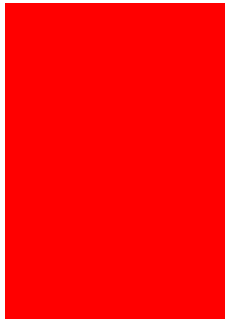
### 5.1.4 Control Measures at the Distribution Network

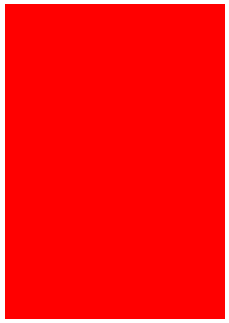
| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| High | Immediate | Water quality assessment along the distribution system | • Residual chlorine and other water quality parameters should be analyzed at pumping stations, booster pumps and random points along the distribution system.<br>• In case of any ingress of contaminants, the location of the contamination can be narrowed down.<br>• Moreover, overall pipeline condition can be estimated. Bio film formation, which is a problem often, encountered in drinking water distribution systems, and detachment can also be assessed. | • Water quality analysis |
| | Immediate | Maintain a clean and hygienic environment in and around the pumping stations | • The usage and spitting of substances such as ghutka should be prohibited inside the pumping stations.<br>• Heaps of solid waste lying around the stations should be shifted to proper disposal sites, and future dumping of solid waste should be strictly banned.<br>• Violators should be penalized. | • Onsite physical inspections |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Intermediate | Providing cemented foundation to booster pumps | • The booster pumps should be provided with a cement foundation and a shelter and be placed at an elevated height to prevent the motors from flooding during rains.<br>• These steps will also reduce the likelihood of having an electric malfunction. | • Onsite physical inspections<br>• The effectiveness of the foundation can be checked after a rain event |
| | Intermediate | Cleaning of water storage tanks | • The water storage tanks at the pumping stations should be cleaned twice a year.<br>• They should be covered with lids. The storage tanks at the pumping stations can be covered with lids easily. Most of the tanks already have reinforced cement concrete ceilings and only require approximately 2x2 ft2 lids. | • Comparison between the quality of water being discharged from pumps and from the storage tanks<br>• Onsite physical inspections |
| | Intermediate | Information management system | • Information management system should be developed.<br>• Moreover, a mobile application should be created for the dissemination of water quality data to consumers and registration of consumer complaints. | • User feedback |
| | Intermediate | Right of way for transmission mains | • The right of way for transmission mains should be ensured.<br>• Neither encroachments nor legal development be allowed near the transmission mains. | • Onsite physical inspections |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Intermediate to Long-term | All illegal and informal connections should be disconnected along with abandoned and old connections. Only approved connections should be allowed. | • Vigilance teams should be constituted to identify, inhibit and prevent all illegal and informal connections.<br>• Only approved connections should be allowed.<br>• The process of team-formation should be transparent, effective and based on merit.<br>• The areas of the city designated to teams should be changed after a certain period to avoid complacency.<br>• The teams should be provided with security guards or police officials when conducting operations.<br>• The teams should include people from the community.<br>• Monitoring cell and complaint center should be established where residents can report regarding water theft and irregularities in their areas anonymously.<br>• An online application should be developed, which would show the current status of the system and where users can lodge complaints. | • Pressure drops<br>• Unaccounted-for water<br>• Public/ community feedback<br>• Analysis of the water flow data from the water metering system<br>• Consumer complaints<br>• Feedback from the local Municipal officials |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Intermediate to Long-term | Standard operating procedures (SOPs) for developmental works | • SOPs should be designed for developmental works especially for which road excavations may be required to reduce the chances of water mains getting damaged.<br>• Special permission and authorization should be required by the office conducting the developmental work from the concerned Municipal officials. The civil works should only be started after getting the required approval.<br>• Standards regarding the size of the excavation and machinery should be used and determined prior to initiating the civil works so that the expected potential risks may be estimated. | • Review of official documents and permits<br>• Less frequent events of pipe damages |
|  | Intermediate to Long-term | Chlorine boosters | • Chlorine boosters should also be installed to maintain the desired residual disinfectant concentrations within the distribution system.<br>• As the water travels within the distribution system, a disinfectant gets consumed along the way. To prevent bacterial reactivation and kill any microbes that may enter the distribution system through repairs and ruptures, a residual disinfectant concentration should be maintained within the system. | • Residual chlorine concentration analysis along the distribution system<br>• Onsite physical inspections |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Intermediate to Long-term | Research and development team | • A full-time research and development team should be recruited for carrying out research activities.<br>• These activities may include by conducting experiments to improve water quality onsite, modifying operating conditions to obtain optimum treatment efficiency, to keep an eye on the current and future researches in water treatment to improve the overall water distribution system, etc. | • Review of research and development activities<br>• Improvement in overall system efficiency |
|  | Long-term | The water-supply lines should be placed at a safe distance from the sewerage lines. | • The water-supply lines should be placed at a safe distance from the sewerage lines to prevent intermixing between the constituents of the pipelines.<br>• Enough space may not be available so the water-supply lines must be placed above the sewerage lines but neither below nor side-by-side. | • Supervision at the time of installation of pipelines<br>• Design blueprints<br>• No trace of fecal contamination in drinking water |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Long-term | Old and leaky pipes should be replaced by new pipes. | • Old and leaked pipes should be replaced by new pipes.<br>• Not only water is wasted through leaks from these pipes but also the old rough surfaces provide a safe and thriving habitat for bacterial pathogens also.<br>• Pipe materials should be selected carefully as the pipes will remain in the system for a long time. Materials less prone to corrosion and rupture to promoting bacterial growth should be encouraged.<br>• Toxic pipe materials such as AC should be disallowed.<br>• A system analysis should be conducted after a set period for identifying old pipes depending on the pipe materials.<br>• Different lifetimes should be assigned to different pipe materials.<br>• Pipes in better condition will not only improve the quality of water but will also save line losses which will eventually add up in the system capacity. | • Less amount of corrosive material in water in the distribution system<br>• Low pressure losses<br>• Reduced unaccounted-for water |
|  | Long-term | Toxic pipe materials | • Pipe materials such as Asbestos Cement (AC) should be replaced with safer materials as soon as possible because of their negative health impacts due to the chronic exposure to asbestos fiber through the ingestion of water.<br>• An expert of pipe materials and infrastructure should be hired and placed on the research and development team mentioned above. | • Water quality analysis |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Long-term | Construction of overhead tanks | • New overhead tanks should be constructed especially in the areas where these are required. Overhead tanks provide head, which then allows the water to reach the consumers.<br>• As long as there will be reduced pressure due to non-availability or a low number of overhead tanks then people will be forced to use pressurized suction motors to get water. | • Onsite physical inspections |
| **Medium** | Immediate | Inspection of pressure chambers | • Pressure chambers should be inspected to look for pressure drops. | • Logbook |
| | Immediate to Intermediate | Avoid negative pressure in transmission mains | • Water should be maintained in the transmission mains to avoid negative pressures. | • Pressure measurements |
| | Intermediate | SOPs for pipe materials for mains, service and consumer lines | • SOPs should be developed for which pipe materials should be used for mains, service and consumer lines.<br>• Flow, pump capacity, pressure, quantity of water and temperature should be considered when selecting the pipe materials. | • Review of the official documents |

| Importance | Period Required for Implementation | Control Identified | Corrective Action | Validation of Effectiveness of Controls |
|---|---|---|---|---|
| | Intermediate | Cleaning of the pipelines | • A safe, effective and economical method should be devised for the flushing of the pipelines. The flushing frequency may depend upon the water quality.<br>• As the water flow and pressure are high in transmission mains along with the presence of a higher residual disinfectant, frequent or exhaustive cleaning may not be required in these pipes.<br>• However, the consumer lines can be flushed with higher concentration of disinfectants once a year after notifying the residents so that they let the taps flow and don't use the water for the time period specified. | • Water quality analysis along the distribution system |
| | Intermediate | Installation of flow meters | • A large portion of the unaccounted water or theft can be reduced substantially by only installing flow meters.<br>• Comparison between government and private meters along the distribution system will help in determining and preventing water theft. | • Onsite physical inspections |
| **Low** | - | - | - | - |

## 5.2 Recommendations for Validation of Control Measures & Prioritization of Risks for all the five MCs

The following recommendations are for all 5 MCs as per the standards / protocols of WHO for development of water safety plan for any type of entity. However each MC can adopt these recommendations as per their applicability.

- **Sources**
  - A new pipeline for Treatment Plant should be installed. Currently, water supplied is highly contaminated in low flow period because of zero flow downstream.
  - There should be either no access to people and animals, or the activities limited one to two kilometers upstream of the water sources.
  - Water quantity supplied should be recorded.
  - Logs of system operated on electricity from grid and standby generator maintained.
  - Water quality at all the sources should be checked regularly to remain aware of any pollutant contaminating the water source.
  - Screens should be installed at inlet points to remove coarse materials, e.g. branches of trees, leaves, plastic bags, etc.
- **Lagoons**
  - Swimming and washing clothes in the lagoons should not be allowed.
  - No houses or animal barns allowed on or around the embankments of the lagoons.
  - Water quality at the inlet and outlet of lagoons should be assessed to measure treatment efficiency.
  - Lagoons should be inspected for silt deposition and weed growth along with proper record-keeping.
  - Devise regular desilting programs to ensure the proper functioning of lagoons in terms of particle-settling, velocity and detention time, short circuiting and to avoid the building-up of organic matter and bacterial growth.
  - The embankments of lagoons should be inspected periodically, especially during and after precipitation events.
  - The outlet chambers of the lagoons supplying water to treatment plants should be covered with easy-to-remove lids.
  - Percolated/seepage water from lagoons may be collected through French drains for reuse.
  - Proper operational procedures should be followed for lagoons. For instance, the water should enter the 1st lagoon followed by 2nd and 3rd lagoons respectively as opposed to the current practice of filling up 2nd and 3rd lagoons before the 1st lagoon and withdrawing water from non-terminal lagoons.
- **Water Treatment Plants**
  - Proper and continuous dosing of coagulants and disinfectants should be done.
  - Chemicals should be injected at the correct stage in the treatment process to maximize the effectiveness of the desired results and to reduce the harmful effects.

- Alum and chlorine, should be stocked and stored at treatment facilities. Storing chlorine is potentially dangerous; therefore, standard health and safety practices should be followed. Currently, the operators handling chlorine are at risk.
- The mixing of untreated and treated water to meet water demand should be stopped immediately. Existing treatment plants need to be expanded to meet the growing needs of the city.
- Overflow rates in clarifiers should be set to achieve the optimum treatment efficiency and quantity of the product water without compromising the quality of the water.
- Regular backwash according to a predetermined head loss should be practiced. Random backwashing may compromise the quality of the filtrate.
- Filter media should be replaced once the filtration efficiency drops below a certain threshold even after backwash.
- Electromagnetic meters should be installed at the distribution point of the treated water to record the water supplied.
- Water quality assessment should be conducted at different treatment processes within the treatment plants.
- The staff working at the treatment plants should be given trainings in addition to hiring experts, especially environmental engineers, to manage the treatment units and processes.

- **Distribution System**

- SOPs should be designed for developmental works, especially for which road excavations may be required, to reduce the chances of water mains getting damaged.
- Old and leaky pipes along with toxic pipe materials such as Asbestos should be replaced with new pipes.
- Materials less prone to corrosion, rupture, and promoting bacterial growth should be used.
- SOPs developed for pipe materials use for mains, service and consumer lines.
- Booster pumps should be provided with a cement foundation and covering at an elevated height to prevent the motors from flooding during rains.
- Residual chlorine and other water quality parameters should be analyzed at pumping stations, booster pumps and random points along the distribution system.
- Install chlorine boosters to maintain the desired residual disinfectant concentrations within the distribution system.
- Recruit a full-time research and development team for carrying out research activities.
- An information management system should be developed.
- Water head should be maintained in the transmission mains to avoid negative pressures.
- Electromagnetic meters be installed along the distribution system to account for water being supplied.
- Water storage tanks at pumping stations and treatment plants should be cleaned and covered.

# CHAPTER 6. MONITORING OF THE CONTROL MEASURES

The WSP team performed operational monitoring to prove that the controls continue to work which includes defining and validating the monitoring of the control measures and developing procedures to verify the efficacy of the control measures.

All control measures identified as “critical” be assigned as “critical control points” and monitored against “critical limits or operational limit” criteria. This critical/ operational limit is a criterion that will indicate whether the control measure is effective and functioning; as it was designed to be.

The WSP team developed a monitoring plan for the whole water supply system indicating an acceptable critical/operational limit and engagement of community for reduction in un-authorized connections and non-revenue water. The team has established a schedule for frequency of monitoring and assigned responsible party to conduct the monitoring.

## 6.1 Operational Monitoring Plan

| Process step | Control measure | Activity | Location | Frequency | Monitor | Critical limit | Corrective action |
|---|---|---|---|---|---|---|---|
| Catchment/Source | Un-authorize encroachments<br>No access to animals<br>Protracted area and fencing | Construction of picnic spots and animal barns | Barrage and Intake Works | Weekly | Inspection by Source Supervisor | Trespass of protracted water zone | Remove Un-authorized construction, disallow public/ animal entry |
| Water treatment plant | Alum and Chlorine | Concentration | At plant | 3 x daily | Chemist | 10-15 ppm<br><br>0.2-1.0 ppm | Adjust dosing as per SOPs |
| Distribution/Storage | Maintain pressure, repair leaks and mosquito proof netting | Water contamination disease | Network and Reservoirs | # x supply timings<br><br>1 x month for storage | Network Operator | Leaked joints and missing netting | Adjust control valves and fix netting |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Consumer awareness | Household water tanks | Household | 2 x random household per week | Plumbing Engineer | Plumbing expert to inspect unhygienic storage | Guide household for hygienic storage practices |

## 6.2 Monitoring Parameters

The parameters for operational monitoring are mentioned below in Table-22. The table indicates which parameter is to be monitored at what step of the treatment train.

**Table 15: Operational Monitoring Parameters for Water Treatment and Distribution** [2]

| Operational parameter | Treatment step/process | | | | | |
|---|---|---|---|---|---|---|
| | Raw water | Coagulation | Sedimentation | Filtration | Disinfection | Distribution system |
| pH | ✓ | | | | ✓ | ✓ |
| Turbidity (or particle count) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Dissolved oxygen | ✓ | | | | ✓ | ✓ |
| Stream/river flow | ✓ | | | | | |
| Color | ✓ | | | | ✓ | ✓ |
| Conductivity (total dissolved solids) | ✓ | | | | ✓ | ✓ |
| Organic carbon | ✓ | | ✓ | | ✓ | ✓ |
| Algae, algal toxins and metabolites | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Alum dosage | | ✓ | | | | |
| Disinfectant dosage | ✓ | ✓ | | | ✓ | |
| Flow rate | ✓ | | | | ✓ | ✓ |
| Microbial presence | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Streaming current value | | | | | | |
| Head loss | | | | | | ✓ |
| CT | | | | | ✓ | |
| Disinfectant residual | | | | | ✓ | ✓ |
| Disinfection by-products | | | | | ✓ | ✓ |
| Hydraulic pressure | ✓ | | | | | ✓ |

[2] Adopted from Guidelines for drinking-water quality: fourth edition incorporating the first Addendum, World Health Organization 2017

## 6.3 Audit at Source

The Auditor will carry out the audit of operational parameters for Source as defined in below format.

**Name of Auditor:** _____ **Date:** _____

**Name of Recipient:** _____

| Location of Activity | Type of Activity | Result | Recommended Action on unusual result |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

## 6.4 Audit in Distribution System

The Auditor will carry out the audit of operational parameters for Distribution System as defined in below format.

**Name of Auditor:** _____ **Date:** _____

**Name of Recipient:** _____

| Location of Activity | Type of Activity | Result | Recommended Action on unusual result |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

## 6.5 Audit at User End

The Auditor will carry out the audit of operational parameters for End Users as defined in below format.

**Name of Auditor:** _____ **Date:** _____

**Name of Recipient:** _____

| Location of Activity | Type of Activity | Result | Recommended Action on unusual result |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

# CHAPTER 7. IMPROVEMENT/ UPGRADATION PLAN

The improvement/ upgrade plan shall be drawn in case existing controls are ineffective and insignificant risks arising to the safety of water in certain areas. This may require the change in infrastructure with improved controls. The improvement/upgrade plans shall include short, medium or long term programs. This will require huge resources as such detailed analysis and careful prioritization will be needed with system assessment. The following water arrangements and allied facilities may be planned to augment with the present water supply system.

## 7.1 Water Quantum Enhancement

The water extension for the population beyond 2040 may be planned and established at feasible locations. The proper water allocation may be secured from regulatory regime to meet the demand of increasing population.

## 7.2 Express Electrical Feeders

It was reported by operational staff that daily load shedding and interruption in electric supply breaks water service for around 8 hours or more which causes low pressure conditions and water contamination in distribution network.

## 7.3 Stock of Chemicals

Adequate stock of alum and chlorine ensured and stored for adequate dosing to provide safe drinking water. Moreover, sufficient number of chlorine cylinders must be procured and kept in stock to address inadequacy of chlorine dosing.

To avoid water contamination, it is essential to operate mains under reasonable pressure say 33ft. to 50ft. head. For distribution system control, it is essential to plan water zoning and each zone serving population of 20,000 – 50,000 may be brought up to a standard and maintain as an up-rated zones, to supply water round the clock. While creating an up-rated zone; following para meters must be ensured:

- Pressure not less than 33ft.
- Detailed survey of zone for valves, fittings and interconnections.
- Schedule of all property connected to mains.
- Check valves and fit new valves where required to isolate zone for testing.
- Fit zone meters to measure flow.
- Provide 2 - 3 pressure tapping points for pressure recorders.
- Inspections of plumbing works of all premises.
- Record reading of zone meters.

The up-rated zone will ensure safe drinking water for consumers and increase water connections which will increase revenue and pave financial base for 5 MCs to run the utility in befitting manner.

## 7.4 Recommendations for upgradation / improvement of WSP in all the five MCs

The following recommendations are for all 5 MCs as per the standards / protocols of WHO for upgradation / improvement of WSP for any type of entity. However each MC can adopt these recommendations as per their applicability.

- Approach to provide express electric feeders to avoid interruption and breaks in water service at main pumping station and balancing reservoirs.
- Ensure adequate storage of alum and stock of chlorine cylinders at filter plants.
- Interlink existing water mains with filter plants and service reservoirs.
- Maintain pressure of not less than 33 ft. in distribution network with proper water regulation with valves.
- Conduct baseline survey for pumping equipment, water leakage and non-revenue water.
- Work out operating costs i.e. tariff rates etc.
- Compile technical specification & cost of pumping system availability through local manufactures/suppliers.
- Water regulation ensured to distribute drinking water judicially to all sections by strengthening the valve system. All the said MCs approach to Sindh Government with proper justification in case of insufficient funds.
- The abstraction of sufficient water from the river Indus and canals must be assured with proper water allocations through Government levels.

# CHAPTER 8. EFFECTIVENESS OF THE WATER SAFETY PLAN

## 8.1 Compliance Monitoring

All control measures should have clearly defined to validate effectiveness and monitoring performance against prescribed limits. The water supply agency requires results from verification monitoring in conformity with water quality targets. For any un-expected results; corrective measures and plans may be developed to respond and ascertain the reasons for variation in water quality. The frequency of monitoring shall be kept according to level of confidence required by water supply agency and its regulatory authorities. The monitoring includes in-depth periodical review at the stages of planned and unplanned changes in water supply system.

## 8.2 Auditing (Internal & External)

Regular and rigorous audits assist in maintaining practical implementation of WSP, ensuring water quality and risks are controlled. Audits may involve internal and external reviews, regulatory and independent external auditors. Auditing can have both an assessment and a compliance checking.

Typically, WSP internal auditing be conducted from weekly to monthly; whereas external WSP audits generally bi-annually and yearly basis. Verification should also include in checking that consumers are satisfied with water supplied.

Auditing is a critical component for verification and ensuring WSP procedures. Verification provides evidence that overall system design and operation is capable of consistently delivering water of the specified quality to meet the health based targets. If it does not fulfill; the upgrade/ improvement plan should be revised and then implemented.

Following three activities for undertaking together to determine the degree of effectiveness of WSP:

- Compliance Monitoring.
- Monitor Consumer Satisfaction.
- Internal and External Auditing of Operational Activities.

**The formal process for verification and auditing of the WSP ensures the effectiveness and proper working.**

**Table 16: Typical Format for Verification and Audit Information**

| Activity | Description | Frequency | Responsible Section | Records |
|---|---|---|---|---|
| Water Quality Monitoring | e-coli is monitored in treated water samples in all zones | At least Weekly | Laboratory | Water Quality Database |
| Calibration Program Audit | Calibration records are audited at all sites for instruments monitoring key control points | At least Quarterly | Quality Monitor / Auditor | Audit Records |

## 8.3 Financial Procedures & Management

Provision of water and sanitation services and modernization of these services in urban areas has become a key challenge in Pakistan. The increasing population and over urbanization aggravates the situation further to maintain the existing services. This creates problems to invest in urban water and sanitation sector infrastructure; which results in lower rate of recovery from the consumers of these services. Consequently, the water and sanitation authorities face financial constraints to mitigate the challenges of infrastructure modernization in general and provision of efficient services in particular. This leads to dissatisfaction of the consumers and affect their willingness to pay for these services. This is a serious drawback in provision of sustainable management of water and sanitation services by the relevant authorities in urban areas. Therefore, the dire need for the sustainable management of water and sanitation services in urban areas should be financial sustainability.

| | |
|---|---|
| **Alum Cost including Transportation & Taxes** | |
| Approximately Rate per metric Ton | Rs. 55,000 |
| Total Requirement | 1710 MT / Year |
| Cost per Year | PKR. 94.05 millions |
| **Chlorine Cost including Transportation & Taxes** | |
| Approximately Rate per metric Ton | Rs. 62,000 |
| Total Requirement | 246.22 MT / Year |
| Cost per Year | PKR. 15.26 millions |
| **Annual Requirement of Funds is PKR. 109.31millions (approximate)** | |

## 8.4 Recommendations for Financial Management and Plans for all 5 MCs

The following recommendations are for all 5 MCs to rationalize their budgets and expenses within the government rules to support WSP initiatives in their respective MCs. However each MC can adopt these recommendations as per their applicability.

- The said 5 MCs should improve financial management and plan to ensure smooth operations and maintenance of water supply system.
- Make efforts to compete all ongoing development schemes on priority basis for betterment of service delivery.
- Organize community awareness programs to improve water services and water charges recovery from users.
- TWC review water tariff on annual basis and register new connections to increase revenue to run entity with support of government subsidy/ funding.
- Install office automation (information management system) in billing systems, water quality, availability of water in reservoirs, etc.
- Develop a mechanism to organize capacity-building program for working staff with automation of office services through latest technology. Planning & Development Board may be requested to support 5 MCs by nominating officers for foreign trainings on priority basis.
- Develop a mechanism to provide adequate funds for purchase of chemical for water treatment as well as for testing laboratories to ensure the quality of water to the users by the government.

# CHAPTER 9. KEY RECOMMENDATIONS / ACTIONS FOR 5 MUNCIPAL COMMITTEES ON WSP

Since the chapter wise specific recommendation are already provided in above sections, however the core actions/matters as outlined below are to be adopted to provide safe drinking water. The basic work of all the five MCs should change, their orientation and begin to perceive primary role as service provider (state of art service providers by fulfilling the basic requirements of their citizens). The MCs should provide integrated water and sanitation services only in response to the effective demand of the consumers. It has to establish the level of services for which the consumer is willing to pay for in order to ensure good public health and environmental standards for the community.

## 9.1 Immediate Actions by all the five MCs

- Organize regular meetings of Municipal Technical Working Group / Party, for recommendations to the Government of Sindh.
- Approach Anti-Encroachment Section, Government of Sindh to clear the encroachment within the premises on immediate basis.
- Conduct blanket survey for illegal connections in houses, commercial areas and factories.
- Conduct baseline survey for pumping equipment, water leakage and non-revenue water.
- Organize community awareness programs to improve water services and water charges recovery from users.
- TWC review water tariff on annual basis and register new connections to increase revenue to run entity with support of government subsidy/ funding.
- Develop a mechanism to provide adequate funds for purchase of chemical for water treatment as well as for testing laboratories to ensure the quality of water to the users by the government.
- Install office automation (information management system) in billing systems, water quality, availability of water in reservoirs, etc.
- Develop a mechanism to organize capacity-building program for working staff with automation of office services through latest technology. Planning & Development Board may be requested to support by nominating officers for foreign trainings on priority basis.
- Disconnect all illegal and informal connections along with abandoned and old connections after survey (recommended above), only approved connections should be allowed.
- Erect fencing around lagoons to restrict public and animals' entry and do not allow swimming and washing of clothes.
- Organize and sponsor frequent workshops on water services and WSP in collaboration with USAID Water Excellence Center and other experts.

- Ensure close coordination with Irrigation department and Sindh Environment Protection Agency (SEPA) for source tracking and water quality assessment.
- Design and develop Information, Education and Communication (IEC) material in local languages and disseminate among the water users.
- Maintain proper record of water quality and quantity by installing Electromagnetic meters, sensors and gauges and log of system operation on electricity from grid and standby generator.
- Engage trained and qualified persons for collection and analyzing water samples at site and laboratory with specified frequency.
- Develop and implement proper monitoring mechanism to ensure WSP effectively
- Make efforts to compete all ongoing development schemes on priority basis for betterment of service delivery.
- Install chlorine boosters to maintain the desired residual disinfectant concentrations within the distribution system.
- Recruit a full-time research and development team for carrying out research activities.
- Approach HESCO to provide express electric feeders to avoid interruption and breaks in water service at main pumping station and balancing reservoirs.
- Design and develop real time GIS Web-Based Application for detailed mapping for the water distribution system attributing each pipeline incorporated (e.g. material type, depth, date installed, and gradient).
- Register the private plumbers who could be involved in plumbing work at household level.
- Approach Government of Sindh to get the approval of the Sindh Water Act for strengthening the recoveries of dues.
- Extra Hypo-chlorinators are required for additional dozing of chlorine at tail end areas pumping stations.
- For close monitoring of Filter Plants, the system of Close Circuits Cameras should be installed which can be monitor at office of the CMOs. This will be extending to all pumping station in future.
- All the 5 MCs should ensure segregation by adopting separate divisions in the Water Management like Production (responsible for Water Treatment at the Filter Plant), Distribution of filter water (responsible equitable water distribution) and O&M (responsible for maintaining of the water supply network and pumping stations).
- Discourage Non-CBA Unions activities for smooth running of the system.
- Establish a Technical Wing staff for better planning of the development works and schemes so that proper record be maintained and the funds may be utilized properly.
- Develop a mechanism to provide adequate funds for purchase of chemical for water treatment as well as for testing laboratories to ensure the quality of water to the users by the government.

## 9.2 Intermediate Actions by all the five MCs

- Prepare a plan and line of action for all the old structures and pipes to be repaired / rehabilitated.
- Develop new water sites for population growth up to 2040 to meet the growing water demand.
- Setup workshop facility for speedy repair and maintenance of mechanical and electrical equipment.
- Undertake plumbing works, installation, piping and fittings of specified standards through qualified technicians/ plumbers as per building plan approved by SBCA office.

## Annex-A Drinking Water Quality Standards

| S. No. | ITEM TO BE TESTED | WHO STANDARDS | MAX: ALLOWABLE CON-CENTRATION. (*) |
|---|---|---|---|
| 1. | Residual chlorine. | 0.30 - 1.00 (mg/1) (C, U) | - |
| 2. | PH | 6.5 – 8.5 (C, FEC, WHO) | - |
| 3. | Colour | < $20^{0}$(EEC, C) | - |
| 4. | Turbidity | < $10^{0}$ (EEC, C) | |
| 5. | Electrical conductivity | 1250 (Us/cm) (EEC) | - |
| 6. | Aluminum | 0.20 mg/1 (Ger) | - |
| 7. | Suspended solids | No Std: available | - |
| 8. | Total Hardness | 350 mg/1 (EEC) | B/W 100 & 500 mg $Cac3^{/L.}$ Normal carbonate alkalinity should not exceed 120 PPM as Cac03. |
| 9. | Alkalinity | No Std: Available | - |
| 10. | Chloride. | 200 mg/1 (EEC, C, WHO | 350 mg/1 **(*)** |
| 11. | Iron (Fe) | < 0.30 mg (WHO, C) | 0.10 mg/1 **(*)** |
| 12. | Manganese (Mn) | < 0.10 mg/l (WHO, C) | 0.10 mg/1 **(*)** |
| 13. | Ammoniacal Nitrogen | < 0.50 mg/1 (EEC) | - |
| 14. | Permanganate Value | < 5mg/1 (EEC, C) | - |
| 15. | - - Subphase (So4) | < 250 mg/1 (C, EEC) | 250 mg/1 |
| 16. | Free Co2 (agressif) | No Std: Available | 0 mg/1 |
| 17. | B. O. D | 5 mg.1 (C) | - |
| 18. | - Nitrate (No 3) | < 50 mg/1 (EEC) | - |
| 19. | Plate Count | < 100 mg 1 (C, U) | - |
| 20. | Albuminoid Nitrogen | < 0.50 mg/1 (EEC) | - |
| 21. | Coliform | 3 / 1 (C, U) | - |
| 22. | Taste | Un objectionable | |
| 23. | Odour | ----- do ----- | |
| 24. | Copper (Cu) | - | 0.05 mg/1 |
| 25. | Zinc (Zn) | - | 5 mg/1 |
| 26. | Calcium (Ca) | - | - |

| S. No. | ITEM TO BE TESTED | WHO STANDARDS | MAX: ALLOWABLE CON-CENTRATION. (*) | |
|---|---|---|---|---|
| 27. | ++ Magnesium (Mg) | - | 125mg/ 1 | |
| 28. | Phenolic substances (as Phenol) | 0.002 mg/1 (*) | 0.001 RPM (**) | |
| 29. | Flour (ide) (F) | - | 1.50 mg/1 (*) | |
| 30. | Lead (Pb) | - | 0.10 mg/1 | **Maximum Allowable conc:** |
| 31. | Arsenic (As) | - | 0.20 mg/1 | |
| 32. | Selenium (Se) | - | 0.05 mg/1 | |
| 33. | Chromium (Cr) | - | 0.05 mg/1 | |
| 34. | Cyanide (Cn) | - | 0.01 mg/1 | |
| 35. | Cadmium (Cd) | - | 0.05 mg/1 | |
| 36. | Barium (Ba) | - | - | |
| 37. | Ammonium ($NH_4$) | - | 0.50 mg/1 (*) | |
| 38. | Free oxygen | - | Min: 5 mg/1 (*) | |
| 39. | Temperature | - | - | |
| 40. | Silica | - | - | |
| 41. | Nitrites (No2) | - | - | |
| 42. | Alkyl benzene sulphate (ABS) | - | 0.50 PPM (mg/1) (**) | |
| 43. | Carbon chloroform sulphate (CEE) | - | 0.20 PPM. | |
| 44. | Total dissolved solids | - | - | |

# Annex-B Formats & Checklists

**Water Sources (Canal Water)**

Location: _____

Operator's Name: _____ Date: _____

Supervisor's Name: _____ Time: _____

| S. No. | Checklist | Yes/No | Observations |
|---|---|---|---|
| 1. | Is the embankment of the canal in proper condition?<br>a. If not, what is the extent of damage?<br>i. Insignificant<br>ii. Needs repair<br>iii. Needs urgent repair<br>iv. Critical<br>b. What are the reasons of damage?<br>i. Rain<br>ii. Trespass of vehicles<br>iii. Wave wash<br>iv. Human activity | | |
| 2. | Any trespass of buffaloes, goats, dogs, or any other animals at water source (2 km upstream of the intake point)? | | |
| 3. | Do you see bathing / washing activity in the water source (1 km upstream of the intake point)? | | |
| 4. | Is the fence around the water source in proper condition?<br>If not, mention the reason and extent of damage. | | |
| 5. | a. Are the bar screens at the water source operational?<br>i. If not, what is the reason of blockage? (Tree branches, Animal bodies, Plastic bag, other floating material).<br>b. What is the head loss in feet?<br>c. Have the bar screens been cleaned? | | |
| 6. | Have the water samples for water quality assessment been collected? | | |

| S. No. | Checklist | Yes/No | Observations |
|---|---|---|---|
| 7. | Have the parameters such as pH, EC, TDS and nitrite been checked onsite? | | |
| 8. | Has the water quality analysis been done? | | |
| 9. | What is the water level at source? | | |
| 10. | What is the water quantity supplied to the lagoon? | | |
| 11. | Is the log book maintained at source?<br>If yes, have you checked pumping time, breakdown / shutdowns and recorded reasons. | | |

**Signature of Person Preparing Report:** _____

**Supervisor's Signature:** _____

**Lagoons**

Location: _____

Operator's Name: _____ Date of visit: _____

Supervisor's Name: _____ Time of visit: _____

| S. No. | Checklist | Yes/No | Observations |
|---|---|---|---|
| 1. | Is the embankment of the lagoon in proper condition?<br>a. If not, what is the extent of damage?<br>i. Insignificant<br>ii. Needs repair<br>iii. Needs urgent repair<br>iv. Critical<br>b. What are the reasons of damage?<br>i. Rain<br>ii. Trespass of vehicles<br>iii. Wave wash<br>iv. Human activity | | |
| 2. | Any trespass of buffaloes, goats, dogs, or any other animals at lagoon premises? | | |
| 3. | Do you see people bathing / washing activity in the lagoons? | | |
| 4. | Is the fence around the lagoons in proper condition? If not, mention the reason and extent of damage. | | |
| 5. | Is the inlet chamber being operational at lagoons? If not, what may be the reason? Choking blocking, or other. | | |
| 6. | Is the designed retention time in the lagoons maintained? If not, what are the reason? | | |
| 7. | What is the gauge level at lagoon? | | |
| 8. | Have the water samples for water quality assessment been collected? | | |
| 9. | Have the parameters such as pH, EC, TDS and nitrite been checked onsite? | | |

| S. No. | Checklist | Yes/No | Observations |
|---|---|---|---|
| 10. | Has the water quality analysis been done? | | |
| 11. | What is the quantity of water being supplied to the treatment plant? | | |
| 12. | What is the extent of silt deposit in inches? | | |
| 13. | Is there a need for desilting the lagoons? If not, report the tentative time for desilting. | | |
| 14. | Is there a significant growth of weed? If yes, does it need de-weeding? | | |
| 15. | Are the French drains operating properly for collection of seepage water? | | |
| 16. | Are the outlet chambers clean and free from objectionable materials, especially, plastic bottles and bags? | | |

**Signature of Operator:** _____

**Signature of Supervisor:** _____

**Water Treatment Plant**

Location: _____

Operator's Name: _____ Date: _____

Supervisor's Name: _____ Time: _____

| S. No. | Checklist | Yes/No | Observations |
|---|---|---|---|
| 1. | How much alum is mixed in water for alum solution? What was the final concentration of the solution? | | |
| 2. | What is the flow of alum solution being mixed in the water? | | |
| 3. | How much chlorine dose is being applied to the water? Report the corresponding turbidity and bacterial count (both before and after chlorination). | | |
| 4. | In case of hypochlorite, what is the concentration of the hypochlorite solution and its flowrate that is being mixed in the water? Report the corresponding turbidity and bacterial count (both before and after chlorine application). | | |
| 5. | What is the status of the chemical stock? Enlist the quantities. | | |
| 6. | Have the samples been collection from each unit process at the treatment plant? | | |
| 7. | Is the design retention time in clarifiers being maintained? If not, what may be the reason?<br>i. Pressing water demand<br>ii. Improper working of scrapers<br>iii. Short circuiting of the water | | |
| 8. | Is the treated water overflowing uniformly from the clarifier? If not, what are the reason?<br>i. Rapid speed<br>ii. Uneven solid deposits on clarifier bed<br>iii. Wind | | |
| 9. | Has the water quality assessment been done? | | |

| S. No. | Checklist | Yes/No | Observations |
|---|---|---|---|
| 10. | Is the cleaning of the alum tanks due? | | |
| 11. | Is the cleaning of the water storage tanks due? | | |
| 12. | Is the replacement/repair of filter media due? | | |
| 13. | Is the backwash interval being met? | | |
| 14. | Is the cleansing of sludge tanks due? | | |
| 15. | Have you detected any leakage from hydraulic structures and conduits? | | |
| 16. | Has the turbidity been removed before the application of the disinfectant? | | |
| 17. | What is the flow rate of treated water supplied to the distribution system? | | |

**Signature of Operator:** _____

**Signature of Supervisor:** _____

**Water Distribution System**

Area/ Location: _____

Operator's Name: _____ Date: _____

Supervisor's Name: _____ Time: _____

| S. No. | Checklist | Yes/No | Observations |
|---|---|---|---|
| 1. | Are the flow meters working? Indicate the meters that are not functional. | | |
| 2. | Are there any leaks in pipes? | | |
| 3. | Are the pipes corroded? | | |
| 4. | Have the water samples for water quality assessment been collected along the distribution system? | | |
| 5. | Have the parameters such as pH, EC, TDS, nitrite and residual chlorine been checked onsite? | | |
| 6. | Has the water quality analysis been done? | | |
| 7. | Are the control valves, air relief valves and reflex valves functional? | | |
| 8. | Have you reported any blockage burst in network? | | |
| 9. | What is the residual chlorine concentration at specific points in the distribution system? Identify the points | | |
| 10. | Is booster pumping station working properly? Report the chlorine dose being injected. | | |
| 11. | Have you checked operating pressure in network at focal locations? | | |
| 12. | When intermediate tanks / reservoir were cleaned and water samples taken? Have you reported water quality of intermediate tanks/storage/reservoir? | | |
| 13. | Have you detected any tempering illegal connection, direct pumping and encroachment on primary network/trunk mains? | | |

**Signature of Operator:** _____

**Signature of Supervisor:** _____

**Pumping Station/Reservoirs**

Area/ Location: _____

Operator's Name: _____ Date: _____

Supervisor's Name: _____ Time: _____

| S. No. | Checklist | Yes/No | Observations |
|---|---|---|---|
| 1. | Are the flow meters working? Indicate the meters that are not functional. | | |
| 2. | Are there any leaks in pipes? | | |
| 3. | Are the pipes corroded? | | |
| 4. | Have the water samples for water quality assessment been collected? | | |
| 5. | Have the parameters such as pH, EC, TDS, nitrite and residual chlorine been checked onsite? | | |
| 6. | Has the water quality analysis been done? | | |
| 7. | What is the quantity of water supplied through pumping station? | | |
| 8. | Is the log book maintained of pumps/equipment? | | |
| 9. | What is the residual chlorine concentration at outlet? | | |
| 10. | Report intermediate dosing injected. | | |
| 11. | Is chlorinator installed at pumping station? | | |
| 12. | Are the control valves operational? | | |
| 13. | What is the water level in the reservoir? | | |
| 14. | Is the cleansing and disinfection of reservoir due? | | |
| 15. | Any tempering, illegal connection or encroachment on feeder mains/water carriers? | | |

**Signature of Operator:** _____

**Signature of Supervisor:** _____

# Annex-C Formats for Source wise SOPs for Water Safety Plan

**SOPs for Source / Catchment**

**CATEGORY**
Water Intakes

**SUB CATEGORY**
Head P.S.
Intake Pumping Station

**SOPS AND GUIDING STEPS**

1. **Samples for water testing**
   - Location of sampling
   - Tests conducted
   - Tests Results
   - Monitor results with water testing standards

2. **Bar Screens**
   - Positioning of screen
   - Rusting and blockage
   - Water flow and level
     Screening quality

3. **Log Book of Pumping Machinery**
   - Record keeping
   - Operating time
   - Monitor pumping flow
   - Interruptions and shutdowns

**FREQUENCY**
Weekly

**RESPONSIBLE OPERATOR** Source Supervisor

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** AEN

**Name:** _____ **Signature:** _____

**Remarks:** _____

**APPROVED BY:** _____ **Signature:** _____

**SOPs for Source / Catchment**

**CATEGORY**
Water Lagoons

**SUB CATEGORY**
Lagoons

**SOPS AND GUIDING STEPS**

1. **Samples for water testing**
   - Location of sampling
   - Tests conducted
   - Tests Results
   - Monitor results with water testing standards

2. **Gauge level North lagoon**
   - Record of level
   - Inflow at inlet
   - Assess water velocity
   - Check flow pattern
   - Monitor silt load

3. **Gauge level South lagoon**
   - Record of level
   - Inflow at inlet
   - Assess water velocity
   - Check flow pattern
   - Monitor silt load

4. **Trespass of public and animals**
   - Check fencing to control illegal access
   - Disallow cattle around lagoons
   - Legal action against direct pumping at lagoons
   - Remove laundries near lagoons

5. **Desilting of lagoons**
   - Monitor silting trend
   - Record silt deposit by sounding
   - Maintain storage capacity of lagoons and water circuiting without obstruction

6. **De weeding of wild growth**
    - Control organic matters in the lagoons
    - Keep wings and lagoon premises clean
    - Remove wild growth at lagoons

**FREQUENCY**
Bi-weekly

**RESPONSIBLE OPERATOR** Supervisor Lagoons

**Name: _____ Signature: _____**

**RESPONSIBLE MANAGEMENT STAFF** AEN

**Name: _____ Signature: _____**

**Remarks: _____**

**Approved by: _____ Signature: _____**

**SOPs for Water Treatment Plants**

**CATEGORY**
Water Treatment Plant

**SUB CATEGORY**
Alum
Chlorination
Clarifiers
Water Quality Testing

**SOPS AND GUIDING STEPS**

1. **Dosing of Alum, Cleaning of Tank and functionality of pumps**
   - Alum concentration
   - Cleansing of Alum tanks
   - Stock of Alum for three months
   - Condition of Alum pumps
   - Record keeping of Alum and dosing

2. **Dosing of Chlorine, and functionality of chlorinators**
   - Dosing of chlorine
   - Stock of chlorine for three months
   - Condition of chlorinators
   - Record keeping of chlorine and dosing

3. **Flocculation and flow rate**
   - Speed of scrapers
   - Quality of flocculated water
   - Remove deposit of solid on structure
   - Uniform overflowing of water from clarifier

4. **TDS, Chemical and Biological Tests**
   - Check rate of filtration
   - Blockage of filter beds
   - Backwashing of filter beds
   - Flow rate of filtered water

**FREQUENCY**
Twice a day

**RESPONSIBLE OPERATOR** Engineer

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF**

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Water Treatment Plants**

**CATEGORY**
Water Treatment Plant

**SUB CATEGORY**
Filtration Units

**SOPS AND GUIDING STEPS**

1. **Cleansing of filter beds and backwash**
   - Check rate of filtration
   - Blockage of filter beds
   - Backwashing of filter beds
   - Flow rate of filtered water

**FREQUENCY**
Daily

**RESPONSIBLE OPERATOR** Engineer

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF**

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Water Treatment Plants**

**CATEGORY**
Water Treatment Plant

**SUB CATEGORY**
Sludge Removal
Machinery / Equipment

**SOPS AND GUIDING STEPS**

1. **Cleansing of tanks**
   - Clean sludge tanks
   - Pump sludge into river

2. **Functionality of pumps**
   - Functionality of sludge pumps
   - Remove sludge in piping

3. **Log Book**
   - Record keeping
   - Operating time
   - Free pumping flow
   - Interruptions and shutdowns

**FREQUENCY**
Weekly

**RESPONSIBLE OPERATOR**

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF**

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Water Treatment Plants**

**CATEGORY**
Water Treatment Plant

**SUB CATEGORY**
Structure and conduits

**SOPS AND GUIDING STEPS**

1. **Hydraulics**
   - Repair leakages
   - Repair valves and fittings
   - Replace worn out pipes/fittings
   - Record keeping of water flows and flow meters

**FREQUENCY**
Fortnightly

**RESPONSIBLE OPERATOR** Engineer

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF**

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Main Pumping Station and Balancing Reservoir**

**CATEGORY**
Pumping Station

**SUB CATEGORY**
Pumping Station

**SOPS AND GUIDING STEPS**

1. **Log Book of Pumps**
   - Record keeping
   - Operating time
   - Free pumping flow
   - Interruptions and shutdowns

2. **Flow Rate**
   - Record water flow
   - Regulate water distribution

3. **Functionality of Pumps including R&M and replacement**
   - Proper working of pumps
   - Repair maintenance of pumps
   - Pumping discharge/pressure

**FREQUENCY**
Twice a day

**RESPONSIBLE OPERATOR** Operator

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Assistant Engineer

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Main Pumping Station and Balancing Reservoir**

**CATEGORY**
Pumping Station

**SUB CATEGORY**
Reservoirs

**SOPS AND GUIDING STEPS**

1. **Gauge Level**
   - Record water level
   - Record inflow and outflow

2. **Cleansing / Disinfection of Tanks**
   - Clean reservoir
   - Disinfection of tank
   - Repair maintenance of leakages

3. **Water Testing**
   - Tests conducted
   - Tests Results
   - Monitor results with water testing standards

**FREQUENCY**
**1**. Twice a day, **2**. Quarterly, **3**. Twice a day

**RESPONSIBLE OPERATOR** Operator

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Engineer

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Main Pumping Station and Balancing Reservoir**

**CATEGORY**
Pumping Station

**SUB CATEGORY**
Structures

**SOPS AND GUIDING STEPS**

1. **Repair and maintenance**
   - Repair and maintenance of pump house
   - Repair and maintenance of sheds
   - Repair and maintenance of pump foundations

2. **Removal of bushes and wild growth**
   - Cut and remove wild growth
   - Keep pumping area clean
   - Keep storage area clean

**FREQUENCY**
**1**. Annually, **2**. Bi-Annually

**RESPONSIBLE OPERATOR** Operator

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Assistant Engineer

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Main Pumping Station and Balancing Reservoir**

**CATEGORY**
Pumping Station

**SUB CATEGORY**
Feeder Mains

**SOPS AND GUIDING STEPS**

1. **Water Quantity and Quality**
   - Water quantity and quality of water carrier
   - Flow rate of water carrier

2. **Preserve ROW from encroachments**
   - Illegal construction within ROW
   - Disallow laying other utility services besides water carrier

3. **Tampering and Illegal Connections**
   - Illegal connection from feeder mains
   - Direct pumping from feeder mains

**FREQUENCY**
**1**. Weekly, **2**. Fortnightly, **3**. Fortnightly

**RESPONSIBLE OPERATOR** Supervisor

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Assistant Engineer

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Main Pumping Station and Balancing Reservoir**

**CATEGORY**
Pumping Station

**SUB CATEGORY**
Pumping Station

**SOPS AND GUIDING STEPS**

1. **Log Book of Pumps**
   - Record keeping
   - Operating time
   - Free pumping flow
   - Interruptions and shutdowns

2. **Flow Rate**
   - Record water flow
   - Regulate water distribution

3. **Functionality of Pumps including R&M and replacement**
   - Proper working of pumps
   - Repair maintenance of pumps
   - Pumping discharge/pressure

**FREQUENCY**
Twice a day

**RESPONSIBLE OPERATOR** Operator

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Assistant Engineer

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Main Pumping Station and Balancing Reservoir**

**CATEGORY**
Pumping Station

**SUB CATEGORY**
Reservoirs

**SOPS AND GUIDING STEPS**

1. **Gauge Level**
   - Record water level
   - Record inflow and outflow

2. **Cleansing / Disinfection of Tanks**
   - Clean reservoir
   - Disinfection of tank
   - Repair maintenance of leakages

3. **Water Testing**
   - Tests conducted
   - Tests Results
   - Monitor results with water testing standards

**FREQUENCY**
**1**. Twice a day, **2**. Quarterly, **3**. Twice a day

**RESPONSIBLE OPERATOR** Supervisor

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Assistant Engineer

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Main Pumping Station and Balancing Reservoir**

**CATEGORY**
Pumping Station

**SUB CATEGORY**
Structures

**SOPS AND GUIDING STEPS**

1. **Repair and maintenance**
   - Repair and maintenance of pump house
   - Repair and maintenance of sheds
   - Repair and maintenance of pump foundations

2. **Removal of bushes and wild growth**
   - Cut and remove wild growth
   - Keep pumping area clean
   - Keep storage area clean

**FREQUENCY**
1. Annually, **2**. Bi-Annually

**RESPONSIBLE OPERATOR** Operator

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Assistant Engineer

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Main Pumping Station and Balancing Reservoir**

**CATEGORY**
Pumping Station

**SUB CATEGORY**
Feeder Mains

**SOPS AND GUIDING STEPS**

1. **Water Quantity and Quality**
   - Water quantity and quality of water carrier
   - Flow rate of water carrier

2. **Preserve ROW from encroachments**
   - Illegal construction within ROW
   - Disallow laying other utility services besides water carrier

3. **Tampering and Illegal Connections**
   - Illegal connection from feeder mains
   - Direct pumping from feeder mains

**FREQUENCY**
1. Weekly, **2**. Fortnightly, **3**. Fortnightly

**RESPONSIBLE OPERATOR** Supervisor

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Assistant Engineer

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Water Distribution**

**CATEGORY**
Network

**SUB CATEGORY**
Control Valves

**SOPS AND GUIDING STEPS**

1. **Operation of valves**
   - Check regulation of water flow
   - Repair and maintenance of leakage in valves

**FREQUENCY**
Twice a day

**RESPONSIBLE OPERATOR** Supervisor

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Assistant Engineer

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Water Distribution**

**CATEGORY**
Network

**SUB CATEGORY**
Pipelines

**SOPS AND GUIDING STEPS**

1. **Flow Rate**
   - Record water flow
   - Regulate water distribution
2. **Operating pressure**
   - Maintain pressure of 33ft at users' end
3. **Water Testing**
   - Focal location of sampling
   - Tests conducted
   - Tests Results
   - Monitor results with water testing standards
4. **Leakage in Network**
   - Check leakages
   - Repair leakages
5. **Repair, Maintenance and Replacement**
   - Repair leaking pipes
   - Replace rusted/worn-out pipes

**FREQUENCY**

1. Twice a day, **2**. Twice a day, **3**. Twice a day, **4**. Weekly, **5**. Need basis

**RESPONSIBLE OPERATOR** Supervisor

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** AEN Maintenance

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs for Water Distribution**

**CATEGORY**
Network

**SUB CATEGORY**
Boosters

**SOPS AND GUIDING STEPS**

1. **Operating pressure**
   - Maintain pressure
   - Boost water flow at users' end

2. **Pumping Log Book**
   - Record keeping
   - Operating time
   - Free pumping flow
   - Interruptions and shutdowns

3. **Water Testing**
   - Focal location of sampling
   - Tests conducted
   - Tests Results
   - Monitor results with water testing standards

**FREQUENCY**
Twice a day

**RESPONSIBLE OPERATOR** Supervisor

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** AEN Maintenance

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs at User End/ Community**

**CATEGORY**
Consumers

**SUB CATEGORY**
Residential

**SOPS AND GUIDING STEPS**

1. **Water Pressure**
   - Maintain pressure at users' end
   - Provide potable water at users' end

2. **Plumbing works**
   - Piping and fittings of standard quality

3. **Hygiene of Tanks / Storage**
   - Random check of tanks and storage including piping, fitting and connection

4. **Water Purity Level**
   - Random testing of water purity

5. **Status of water connection**
   - Registered water connection
   - Regularize illegal connection

**FREQUENCY**

1. Weekly, **2.** Monthly, **3.** Monthly, **4.** Monthly, **5.** Monthly

**RESPONSIBLE OPERATOR** Supervisor

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** XEN Maintenance

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs at User End/ Commercial**

**CATEGORY**
Consumers

**SUB CATEGORY**
Commercial

**SOPS AND GUIDING STEPS**

1. **Flow Meter**
   - Functionality of flow meter
   - Record meter reading
   - Tempering with flow meter

2. **Status of water connection**
   - Registered commercial connection
   - Regularize illegal connection
   - Check billing and recovery

**FREQUENCY**
Monthly

**RESPONSIBLE OPERATOR** Inspector

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Manager Taxation

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

**SOPs at User End/ Bulk**

**CATEGORY**
Consumers

**SUB CATEGORY**
Bulk

**SOPS AND GUIDING STEPS**

1. **Water Pressure**
   - Maintain pressure at bulk end
   - Provide potable water at bulk end
2. **Hygiene of Tanks / Storage**
   - Joint inspection with bulk consumer of tanks / storage including piping, fitting and water meter
3. **Water Purity Level**
   - Random sampling to determine water purity
   - Obligation of bulk consumer for internal distribution
4. **Flow Meter**
   - Functionality of flow meter
   - Record meter reading
   - Tempering with flow meter
5. **Status of water connection**
   - Registered bulk connection
   - Regularize illegal bulk connection
   - Check billing and recovery

**FREQUENCY**

1. Weekly, **2**. Monthly, **3.** Monthly, **4.** Monthly, **5.** Monthly

**RESPONSIBLE OPERATOR** Inspector

**Name:** _____ **Signature:** _____

**RESPONSIBLE MANAGEMENT STAFF** Manager Taxation

**Name:** _____ **Signature:** _____

**Remarks:** _____

**Approved by:** _____ **Signature:** _____

## Annex-D Log Books

**LOG BOOK FOR LAGOON**

Location: _____

Lagoon Name: _____

Capacity: _____ Gallons

| Date | Pumping time - Inlet (hrs) | | Pumping time – Outlet (hrs) | | Flow in (GPM) | Flow out (GPM) | Initial water level (m) | Final water level (m) | Reason for shutdown (if any) | Remedial measures | Operator's Signature |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Start | Stop | Start | Stop | | | | | | | |
| | | | | | | | | | | | |
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**Reasons for Shutdown:** (Rest, Repair, Mechanical/Electric Fault, Power interruption, Blocking/Leakage in suction/delivery, Manifold, any other).

**LOGBOOK FOR WATER TREATMENT PLANT**

Location: _____

Name of the treatment plant: _____

Capacity: _____ GPD

| Date | Operational time (hrs) | Non-operational time (hrs) | Alum used (kg) | Chlorine used (kg) | Water treated (gal) | Water supplied without disinfection (gal or hrs) | Initial water level in the storage (gal) | Final water level in the storage (gal) | Operator's Signature |
|---|---|---|---|---|---|---|---|---|---|
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**Reasons for Shutdown:** (Rest, Repair, Mechanical/Electric Fault, Power interruption, Blocking/Leakage in suction/delivery, Manifold, any other).

**LOG BOOK FOR PUMPING STATION**

Location: _____

Pump/Equipment: _____ Type: _____

Capacity: _____ GPM

| Date | Pumping Time (hrs) | | | Reasons of Shutdown | Electric Breakdown (hrs) | Remedial measures | Signature Operator |
|---|---|---|---|---|---|---|---|
| | Start | Stop | Total | | | | |
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**Reasons of Shutdown:** (Rest, Repair, Mechanical/Electric Fault, Power interruption, Blocking/Leakage in suction delivery, Manifold, any other).

## Annex-E Format for Water Quality Test Report

**Water Quality Test Report (Format)**

**Sample Collection Date: _____ Sample Collection Time: _____ Lab Code: _____ Reporting Date: _____**

**Analysis Location: _____**

| S # | Parameter | | Color (Pt-Co) | Odor | pH | Turbidity (NTU) | TDS (mg/l) | EC (µS/cm) | Calcium (mg/l) | Magnesium (mg/l) | Sodium (mg/l) | Potassium (mg/l) | As (ppb) | Alkalinity (mg/l) | Bicarbonate (mg/l) | Carbonate (mg/l) | Chloride (mg/l) | Hardness (mg/l) | Fluoride (mg/l) | Sulfate (mg/l) | Nitrate (mg/l) | Fecal Coliforms (CFU/ 100ml) | E.Coli (CFU/ 100ml) | Total Coliforms (CFU/ 100ml) | Remarks | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard | WHO/NEQS/SEPA Guidelines | ≤ 15 TCU | TON | 6.5-8.5 | < 5 NTU | < 500 mg/l | < 500-800 mg/l | 75 mg/l | 30 mg/l | 20 mg/l | 12 mg/l | 0.05 mg/l (50ppb) | 20-200 mg/l | | | < 250 mg/l | < 500 mg/l | 1.5 mg/l | 250 mg/l | < 50 mg/l | Must not be detectable in 100 ml sample | Must not be detectable in 100 ml sample | Must not be detectable in 100 ml sample | Fit | Unfit |
| 1 | Catchment/ Canal/Intake | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Lagoon In | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Lagoon Out | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Clarifier Out | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Filter Bed Out | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | After Disinfection | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Water Distribution System | | | | | | | | | | | | | | | | | | | | | | | | | |

**Chemist Name:** **Signature: _____**

**Reported to: The Engineer** **Signature: _____**