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Water Safety Plan

Managing drinking-water quality from catchment to consumer for Iraq

UNICEF-WASH

Iraq Country Office

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List of abbreviations

WSP	Water Safety Plan
MoEH	Ministry of Health and Environment
DoH	Directorate of Health
ISO	International Organization for Standardization
SOP	Standard Operating Procedure
DMS	Data Monitoring System
WHO	World Health Organization
TDS	Total Dissolved Solids

Chapter 1

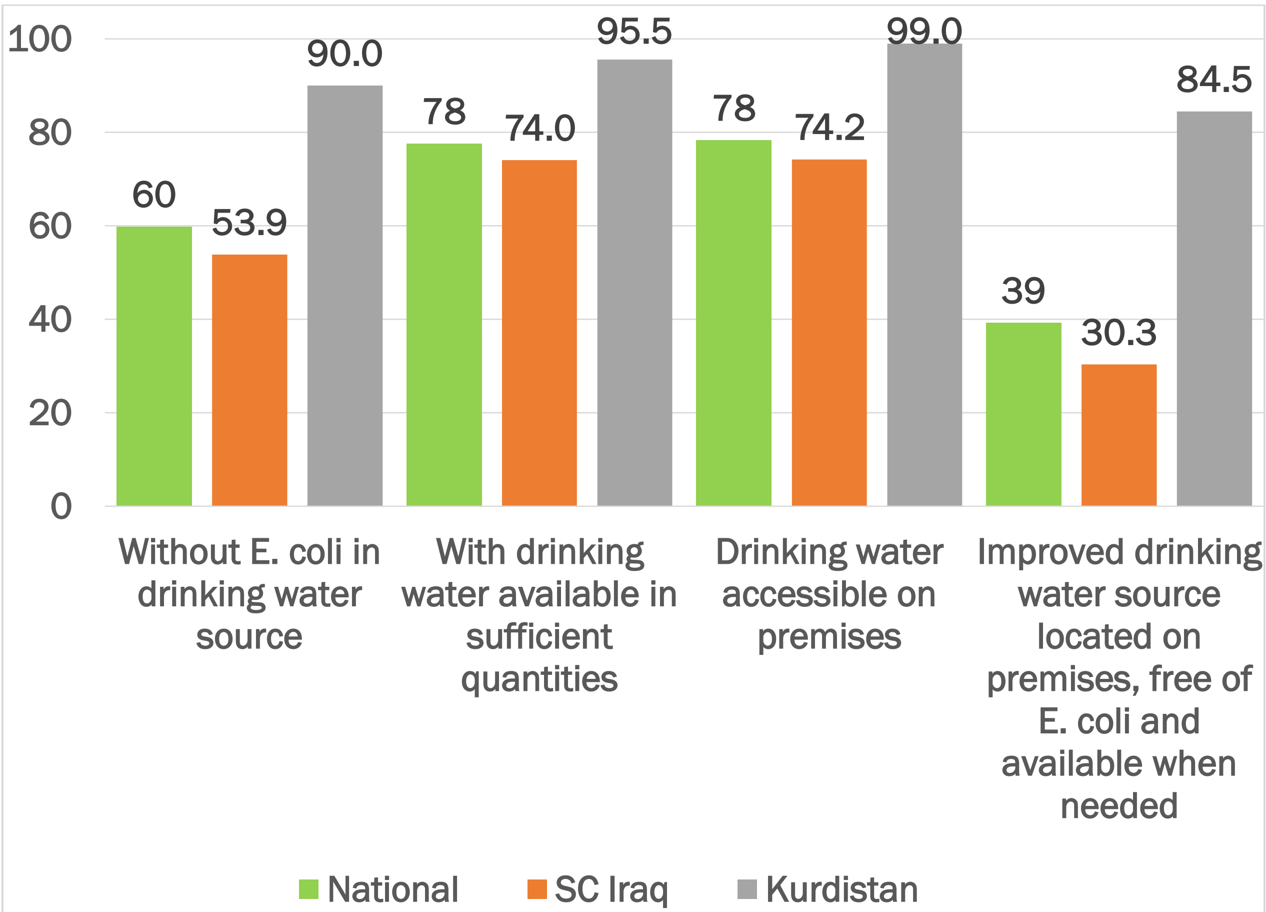
INTRODUCTION

As Iraq's population grows and rapidly urbanizes, the requirements for quality drinking water and sanitation services increases. An expanding and diversifying economy would increase the demands on the water resource. Government efforts to expand agriculture, which already utilizes up to 90% of available raw water resources, have increased the strain on the country that already suffering from significant water stress. Iraq faces an acute water crisis, resulting from weak constitutional or legislative framework which need to be strengthened and expanding the limitation and capacities in order to manage and monitor water resources and control water consumption.

Although about 86.6% of Iraqi population had access to drinking water supply network, however, in 2016, only 60% of households had access to chlorinated water, leaving 2 households in 5 at risk of evitable water-borne diseases (Environmental survey 2016). Reports from the Iraqi Ministry of Health and Environment (MoHE) indicate that bacteriological contamination in the water supply varies between governorates, ranging from 2.5% up to 35%. The average of 18% bacteriological contamination highly exceeds the Iraqi National Drinking Water Standards and WHO Guidelines for drinking (less than 5%), compared with MICS 6 results which showed the average proportion of Iraqi population have access to safely managed water equitable access to safe and affordable drinking water from an improved water source which is located on premises, available when needed and free of faecal and priority contamination only 39.2 per cent.

Water Supply/Demand: Current estimates indicate that water supply to urban areas provides 96% coverage. In rural areas, this falls to 87%. Water services are limited to a few hours per day, and the water is often of poor quality and in many cases undrinkable. A low water tariff rate, combined with the lack of awareness about water scarcity, leads to daily consumption of 392 litres per capita per day that exceeds the international average of 200 litres. The below recent MICS6 results show the coverage of basic water, sanitation and hygiene including the disparities between the different zones, urban and rural areas.

The 2030 agenda represents the opportunity to shape a healthier, better world. The SDGs have aimed higher water and sanitation for all, including a new emphasis on water quality, availability, affordability and accessibility. The SDG targets relating to drinking water, sanitation and hygiene are much more ambitious than the MDGs to achieve universal access to safely managed services (SDG 6.1 and 6.2).



Sustainable Development Goals (SDGs)

SDGs goals indicators and targets of the 2030 Agenda which should be disaggregated, where relevant, by income, sex, age, race, ethnicity, migratory status, disability and geographic location, or other characteristics, in accordance with the Fundamental Principles of Official Statistics. This WSP contributes to achieving goal 6 which is targeting the following:

1- By 2030, achieve universal and equitable access to safe and affordable drinking water for all
2- By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.
3- By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

4- By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from
5- By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
6- By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
7- Support and strengthen the participation of local communities in improving water and sanitation management

Traditionally, there has been a curative approach to public health aspects of drinking water quality management whereby waiting for the results of water quality tests, or consumer perception regarding perceived health, before action is taken. This approach has some success, but it was not sufficient to represent a preventive public health protection strategy. Nowadays, worldwide has adopted a new approach to protecting public health by reducing waterborne disease and preventing outbreaks by providing a comprehensive framework for assuring the quality of water through systematic assessment and management of health risks which is called Water Safety Plan (WSP).

The Water Safety Plan (WSP) approach is an iterative method focused on analyzing the risks of water contamination in a drinking water supply system, from catchment to consumer, in order to protect human health. This approach is aimed at identifying and drastically reducing water contamination in the entire drinking water system, through the identification and mitigation or, if possible, elimination of all factors that may cause a chemical, physical, microbiological risk for water in order to understand which the preliminary evaluation aspects are to be considered in the elaboration of a WSP. The WSP is very useful not only as a risk mitigation approach, but also as a cost-effective tool for water suppliers. Furthermore, this approach will reduce public health risk, ensure a better compliance of water quality parameters with regulatory requirements, increase confidence of consumers and municipal authorities, and improve resource management due to intervention planning. Further, some new control measures are proposed by the WSP team within this work.

The WSP guidance provides a suitable system for guiding the systematic assessment, management and monitoring of drinking water quality risks. There are many matches between the WSP and the general management system standards, such as ISO 9001, ISO 22000 and HACCP.

(WSP) is widely considered to be the most effective methodology of consistently ensuring the safety of a drinking-water supply.

The WSP has a new modern approach makes it live system in addition to all WSP requirements. The new approach relies on digitizing WSP by digitalizing all business steps, communication, documentation, and automatic analyses. The benefits from digitizing the WSP could be summarized as the following:

- Support the communications among all the authorized officers and get quick understanding and solving any risks related to water quality.
- Support the management system including the operation and monitoring process through collecting and analyzing data through the developed online system.
- Support the validation by using this online system since it will make the documentation process easier and faster.
- The system will provide comprehensive database that can be used later to analyze the WSP components and evaluate the weaknesses in the system in order to provide permanent solution and could be used for establishing strategic plans for the country.
- Reduce the contradiction between the service provider and surveillance, since, they have started to use unified standard operating procedures through the application of the ISO system they are following.

Water Safety Plan and Benefits

A WSP follows a comprehensive risk assessment and risk management approach that encompasses all steps in water supply, from catchment to consumer, and considered as a valuable tool to help water suppliers and effectively operate and manage the water supply system.

The aim of a WSP is very straightforward to consistently ensure the safety and acceptability of a drinking water supply.

The development and implementation of the WSP approach for each drinking-water supply is as follows:

- Set up a technical team and decide the appropriate methodology by which WSP will be developed;
- Identify all the hazards and hazardous events affect the safety of water supply from the catchment from treatment and distribution to the consumers' point of use;
- Assess the risk presented by each hazard and hazardous event;
- Consider if controls or barriers are in place for each significant risk and if these elements are effective;
- Validate the effectiveness of controls and barriers;
- Implement an improvement plan wherever necessary;
- Demonstrate the system is consistently safe;
- Regularly reviewing the hazards, risks and controls;
- Keep accurate records for transparency and justification of the outcomes.

There is no limited modality to implement WSP however, and according to the WHO guideline, there is a clear strategy shown with several examples in many countries. It is essential that WSP approach fits in with the way a utility is organized and operates. Water utility will take the lead in the WSP approach and will have responsibilities towards ensuring the safety of water and for them to work with the water utility on risk reduction.

1.1 Digital Monitoring System (DMS)

The new approach initiated and developed provided by UNICEF- WASH programme in Iraq designed and implemented a Digitalized Monitoring System DMS for the WSP.

This could be defined as a tool that using the online system to record the data collected from identified local staff including the quantity and the quality of water from the source (Tigris, Euphrates rivers mainly and any other bodies of water) and the data collected from the treated water from the water treatment plants. Despite that fact, UNICEF has piloted two Iraqi governorates (Baghdad and Kirkuk) to conduct WSP, UNICEF built the first seed and took into consideration building on the fundamental DMS to maximize and cover other governorates. The new system is designed to cover all management levels of authorities including water service providers and the surveillances as follow:

A- Water supplier level:

1- Operators: Having authorities to access the system and upload data daily collected from the source and the treated water (from production facilities) in order to be analyzed by the system and present the results on water quality and the potential risks to the head of water project and water laboratory departments as well as decision-Makers.
2- Head of departments: Have the authority to review, arrange, and ensure the accuracy of the entered data in order to be presented properly to the decision maker, then immediate corrective action shall be made in case of any risk is reported
3- Decision-Maker: Have the authority to access to the supply system and surveillance feedback including the results of the analysis which shows quantity and quality levels of water in order to make decision through taking the mitigation and corrective measures. These authorities are managers or general managers level at the Ministry of Municipality and or including the Minister and the Prime Minstar of Iraq office.

B- **Surveillance level:**

An effective surveillance system includes independent oversight of the entire drinking-water system and all supply types, with strong legislation supporting the surveillance agency. In assessing the adequacy of supplies, surveillance entities should take account of the following considerations: quantity, accessibility, affordability, continuity and quality.

With regard to the latter, entities should assess whether the quality of the water supply is regularly verified and complies with relevant standards; whether compliance or non-compliance with those standards results in an unacceptable public health burden; and whether an approved water safety plan for the supply is in place. The method adopted can entail either direct assessment or an audit-based approach; in either case, it should be adapted to the specific circumstances of the supply (urban areas, small-scale water supplies, household water treatment and storage.

Surveillance level includes the following:

1- Delegated local staff whom work at the Ministry of Health and Environment (MoHE) laboratories that required to test the quality of water collected and feed data in DMS;
2- Supervisors or head of laboratories ensure the accuracy of water quality test procedures to measure the required parameters;
3- Decision-maker at the Ministry of Health and Environment level who have the delegation to approve or disapprove the quality of produced water provided by the Ministry of Construction, Housing and Public Municipality.

By implementing the new digitalized system in Iraq and adopt this methodology will enable the surveillance to have full understanding of water quality and will help the authorities establish short- and long-term water resource management plan on water quality and quantity.

1.2 Current Management Approaches

In drinking-water, a wide range of both chemical and microbial contaminants, some of which can have adverse health effects on consumers for instance, the water treatment process.

Water supply systems can be considered as a number of steps aimed at assuring the safety of drinking-water, including:

- Preventing pollution of source waters;
- Selective water harvesting;
- Controlled storage;
- Treatment prior to distribution;
- Protection during distribution; and
- Safe storage within the home and, in some circumstances, treatment at the point of use.

One of the main keys to resolve the water issue is understanding the source, fate and transport of such contaminant in order to have successful solution.

One of the significant strategies in providing safe drinking-water to the consumer is the multiple barrier approach. As the detection and listing of pathogenic microorganisms from microbial contaminated water is always difficult and expensive reliance has traditionally been placed on the examination for microbial indicators of pollution. The indicators are typically non-pathogenic bacteria, which are present in faucal material in large amounts. Their enumeration is relatively easy and inexpensive (in comparison with that for individual pathogens). Microbial contaminants, however, are not limited to bacteria and illness may result from exposure of contaminant which have different environmental fate and transport characteristics to bacteria. Therefore, the testing of water immediately prior to, or within, distribution (end-product testing) can only highlight a possible health problem after the water has been consumed.

1.3 The Basis for Water Safety

The most cost-effective and preventive action means of consistently assuring a supply of acceptable drinking-water is the application of risk management procedure and monitoring procedure. It is important that the risk management is comprehensive and, needs to cover the whole system from catchment to consumer (Figure 1.1)

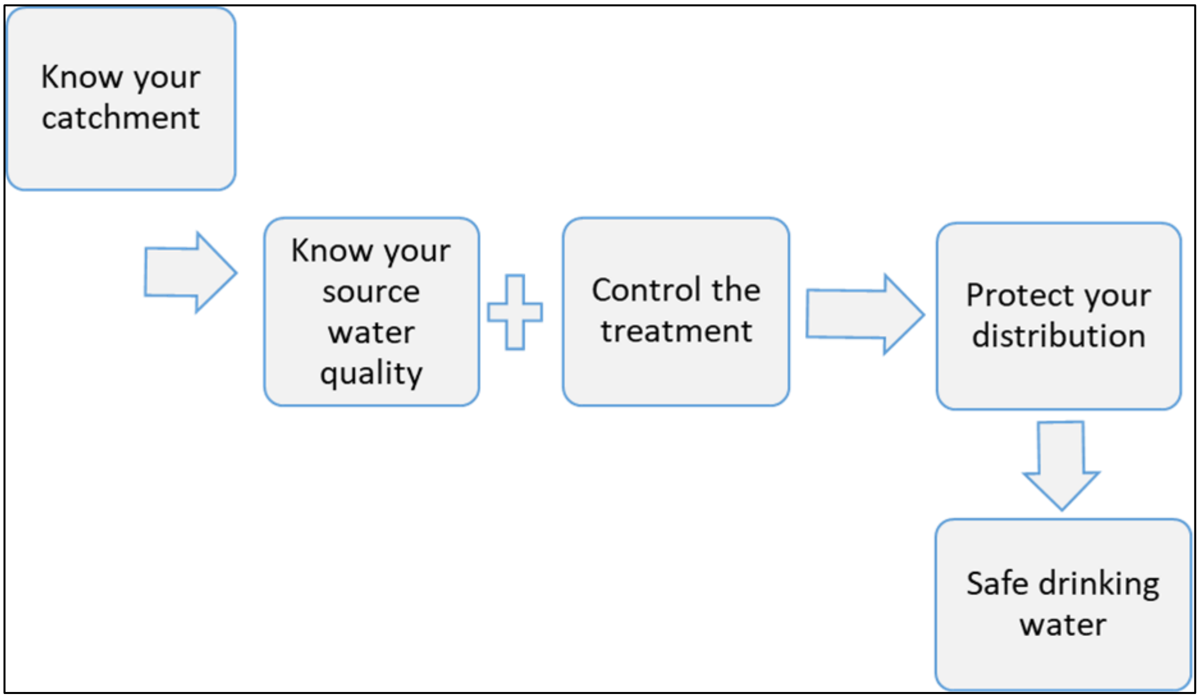


Figure 1.1: 'Catchment to consumer' approach to risk management of the safety of drinking water (Medema et al. 2003)

Box 1.2: Framework for safe drinking-water Figure 1.2. (WHO 2004)

Key components:
- Health based targets (based on an evaluation of health concerns).
- System assessment (to determine whether the water supply chain (from source through treatment to the point of consumption) as a whole can deliver water of a quality that meets the health-based targets.
- Operational monitoring of the control measures in the supply chain, which are of particular importance in securing drinking-water safety.
- Management plans (documenting the system assessment and monitoring; describing actions to be taken in normal operation and incident conditions – including upgrade and improvement), documentation and communication.
- A system of independent surveillance that verifies that the above are operating properly.

Water safety plan, therefore, includes system assessment and design, operational monitoring and management plans as well as documentation and communication.

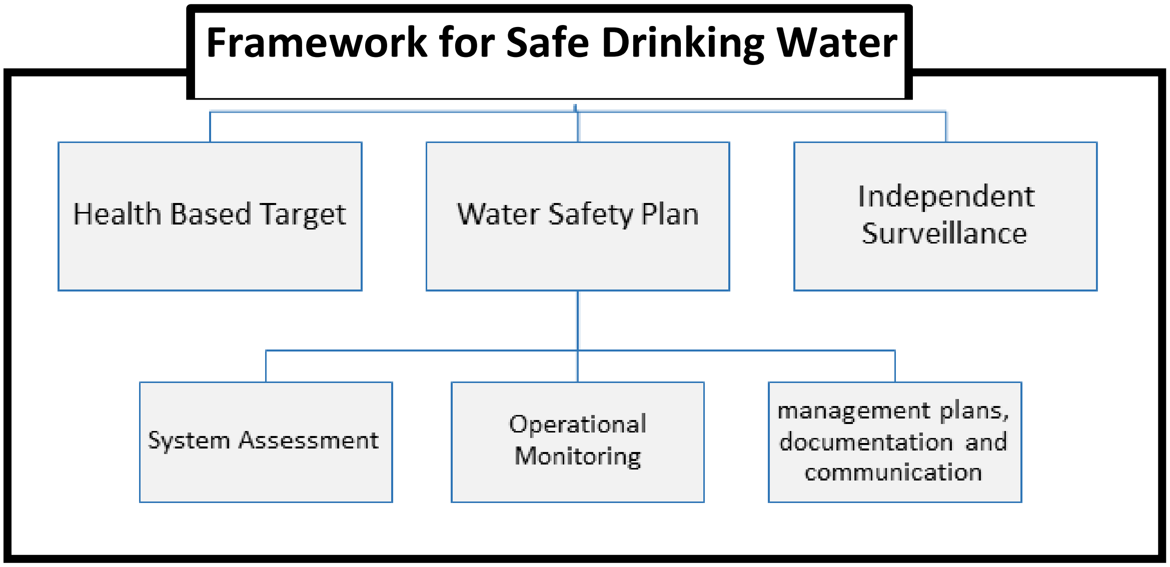


Figure 1.2: Framework for safe drinking-water

1.3.1 Health-based targets

Health-based targets provide the foundation for the application of the guidelines to all types of water supply. The purpose of setting targets is to mark out indicators to guide and chart progress towards a determined health and/or water quality goal. The targets considered as an essential part of health policy development.

Health-based targets provide a 'benchmark' for water suppliers by providing information against which to evaluate the adequacy of existing installations and support in identifying the level and type of examination and analytical verifications applicable and in developing auditing structures. Health-based targets support the development of water safety plans and verification of the effective implementation. In reality the process of target formation and water safety plan description is likely to be iterative with each feeding into the other. Health-based targets represent the overall policy objective for water safety as distinct by what is considered an suitable level of risk (e.g. WHO guidelines for carcinogens use 10-5 excess lifetime risk of cancer and microbiological recommendations apply 10-4 excess annual risk of infection, these targets are broadly equivalent in terms of health burden). However, if a water supply(s) cannot meet health-based targets this does not mean that the water safety plan cannot be defined. A water safety plan should be defined, and an estimate should be made of current risk excess.

From this, two policy decisions may occur; Firstly, there is an investment programme to upgrade the infrastructure or operating procedures or invest in catchment management which will guarantee the water safety plan will meet the targets (with appropriate relaxations and exemptions in place during the interim). Secondly the excess risk may be accepted because it is shown to be quite low contributor to overall national disease burdens and the costs of reducing the excess would divert funds away from other activities with a better prognosis for public health improvement. Equally, as water safety plan is developed, health-based targets may be revised the new levels of safety that may be achieved.

Different types of target will be applicable for different purposes so that in most countries several types of targets may be used for various purposes. In developing countries, significant attention must be taken to develop targets that account for the exposures of disease sources. Attention must also be taken to return the advantages of progressive, incremental improvement that will often be based on multiple categorization of systems to broad categories of public health risk rather than having a single but hard to achieve health-based target at the upper end. In addition, even for a system that cannot achieve a desired health-based target, the implementation of a water safety plan can assist in operating that system optimally, to minimize then incidence of disease attributable to that system. Elements of drinking-water may cause adverse health effects from single exposures (e.g. microbial pathogens) long-term exposures (e.g. many chemicals). Due to the range of constituents in water, their mode of action, and nature of fluctuations of concentrations, there are four principle types of health-based targets used as a basis for identifying safety requirements (outlined below and in Table 1.1)

- **Health outcome targets:** In some circumstances, especially where water-related/waterborne disease contributes to a measurable burden, reducing exposure through drinking-water has the potential to noticeably reduce overall occurrence of diseases. It is likely to establish a health-based target in terms of a measurable reduction in the overall level of diseases. This is valid where adverse effects follow shortly after exposure, are readily and reliably monitored and where changes in exposure can also be monitored readily and reliably. This type of health outcome target is primarily applicable to some microbial hazards in developing countries and chemical hazards with clearly defined health effects largely attributable to water (e.g. fluoride). In other circumstances health outcome targets may be the basis for evaluation of results through quantitative risk assessment models. In these cases, health outcomes are estimated based on information concerning exposure and dose-response relationships. The results may be employed directly, as a basis for the specification of water quality targets or provides the basis for development of other health-based targets;

- **Water quality targets:** this type of targets designed for individual drinking-water constituents which signify a health risk from long-term contact and where fluctuations in concentration are small or occur over long periods. They are normally expressed as Guideline values (concentrations) of the chemicals of concern.
- **Performance targets:** The performance targets are employed as part of the drinking-water management system for constituents where short-term exposure represents a public health risk, or where large fluctuation in numbers or concentration can occur over short periods of time with significant health inferences. They are normally expressed in terms of required decreasing of the substance of concern or effectiveness in preventing contamination;

- **Specified technology targets:** Usually considered the national regulatory which may establish targets for specific actions for smaller municipal, community and household water supplier. These types of targets may categorize specific permissible devices or processes for given situations and/or generic drinking-water system types.

Table 1.1 Heath Based Target analysis

Type of Target	Name of Target	Typical Application	Assessment
Health Outcome			
Epidemiology based	Reduction in detected disease incidence or prevalence	Microbial or chemical hazards with high measurable disease burden largely water associated	Public health surveillance and analytical epidemiology
Risk assessment based	Tolerable level of risk from contaminants in drinking-water, absolute or as a fraction of the total burden by all exposures	Microbial or chemical hazards in situations where disease burden is low and cannot be measured directly	Quantitative risk assessment
Water Quality			
	Guideline value applied to water quality	Chemical constituents found in source waters	Periodic measurement of key chemical constituents to assess compliance with relevant guideline values
	Guideline values applied in testing procedures for materials and chemicals	Chemical additives and by-products	Testing procedures applied to the materials and chemicals to assess their contribution to drinking-water exposure taking account of variations over time.
Performance			
	Generic performance target for removal of group of microbes	Microbial contaminants	Compliance assessment through system assessment and operational monitoring
	Customized performance targets for removal of groups of microbes	Microbial contaminants	Individually assessment would then proceed as above reviewed by public health authority; would then proceed as above
	Guideline values applied to water quality	Threshold chemicals with effects on health which	Compliance assessment through system

		vary widely (e.g. nitrate and cyanobacteria)	assessment and operational monitoring
Specified technology			
	National authorities specify specific processes to adequately address constituents with health effects (e.g. generic/model water safety plans for an unprotected catchment)	Constituents with health effect in small municipalities and community supplies	Compliance assessment through system assessment and operational monitoring

It is essential that health-based targets, defined by the relevant health authority are realistic and under local operating conditions and are set to protect and improve public health.

1.3.2 Water Safety Plan

The core objectives of a water safety plan are to confirm safe drinking-water through good water supply practice which include:

- To prevent contamination of water at source;
- To treat water to reduce or remove contaminations that could be present to the extent necessary to meet water quality targets; and
- To prevent re-contamination during storage, distribution and handling of drinking-water.

The focus of this document is the development and implementation of the Digital Management System (DMS) in the water safety plans to be used by the service providers to water sector in Iraq.

1.3.3 Surveillance

The third main component of the framework for safe drinking-water is surveillance. Surveillance contributes to the protection of public health by indorsing improvement of the quality, quantity, access, affordability, and continuity of water supplies and is complementary to the quality control function of the drinking-water supply agency. Surveillance does not remove or replace the responsibility of the water supplier to ensure that a water supply is of acceptable quality and meets pre-determined health based and other performance targets. One of the roles of surveillance is to allow for legal redress in pursuing safe drinking-water. Surveillance is also used to ensure that any transgressions that may occur are appropriately investigated and resolved. In many cases, it will be more appropriate to use surveillance as a mechanism for collaboration between health agencies and water suppliers on improving water supply rather than resorting to enforcement, particularly where the problem lies mainly with community-managed water supplies. Surveillance requires a systematic programme of surveys that may include auditing of water safety plans, analysis, and sanitary inspection and institutional and community aspects. It should cover the whole of the water supply system, including sources and activities in the catchment, transmission infrastructure (whether piped or un-piped), treatment plants, storage reservoirs and distribution systems.

Chapter 2
ASSEMBLE THE WSP TEAM, ROLES, RESPONSIBILITIES AND LEGAL ASPECTS

There are number of stakeholders who play an important role in the provision of safe drinking-water, these include public health authorities, local authorities and water service providers. The roles and responsibilities of each of these stakeholders are examined in turn. The legal aspects of drinking-water supply, and the role that water safety plan may play, are covered in a separate section.
In Iraq, water supply authority is primarily responsible for managing water supply system who is leading the WSP, develop and implement of the WSP, This entity could be responsible for controlling water quality while the water quality also needs surveillance roles where the ministry of health is responsible, through hundreds of primary healthcare centers available at the community level.

2.1 Roles and Responsibilities in the Provision of Safe Drinking-Water

The water quality management aspects are regularly outside the direct responsibility of the water suppliers, it is essential joint of multi-agency approach that should be adopted to ensure that entities with responsibility for specific areas within the water cycle are involved in the management of water quality. Important example is where catchments and source water are beyond the drinking-water supplier’s dominion. Consultation with other authorities is necessary for other fundamentals of drinking-water quality management, such as monitoring and reporting requirements, emergency response plans and communication strategies.
Major stakeholder’s decisions or activities that could affect or be affected the drinking-water supplier should be encouraged to coordinate their planning and management activities where appropriate. For example, health or resource management entities and consumers, industry and plumbers. Appropriate mechanisms and documentation should be established for stakeholder commitment and involvement to ensure more transparency and receive beneficiary feedback on the quality of produced water.

The new WSP system in Iraq will merge all team members together through an online network to facilitate communication, information sharing, and best documentation, since, the team can use an official document to record information of team members like (contact numbers, skills, role, etc..) as shown in Table 2.1. Including all experiences could be available for use with the ability to be a source of capacity building of Water Authority and Surveillance members where:

1- The team is responsible for developing, implementing and maintaining the WSP as a core part of their day-to-day roles.
2- The team is responsible to set out how the WSP approach is to be implemented and the methodology that will be used, particularly in assessing risk.
3- The team members need to collectively have the required skills to identify hazards and understand how the associated risks may be controlled.
4- The team should appoint a team leader to drive the project and ensure focus.
5- The team will have the authority to monitor and review data from the online WSP system or any needed information as required,
6- The team can communicate with WSP members from other entities and give a recommendation accordingly.
7- The team should define and record the roles and responsibilities of the individuals on the team to divide responsibilities among the team members at the start of the process.

Table 2.1. Official document to record information of team members

Baghdad - Water Safety Plan Team						
No.	**Name**	**Position**	**Skills**	**Role in Water Committee**	**location of duty and responsibilities**	**Contact Details (Address/Phone/E-mail)**
1						
2						
3						

2.2 Assemble the Water Safety Plan Team

Assembling the WSP team is the preliminary step to develop the water safety plan. For large supplies, a multi-disciplinary team of main people should be assembled to develop the plan. This should include managers, engineers (operations, maintenance, design, and capital investment), water quality controllers (microbiologists and chemists) and technical staff involved in day-to-day operations. All members of the team should have a good understanding of the system.
The leader of the WSP team should be appointed to drive the project and ensure focus. The team leader should have the authority, organizational and interpersonal skills to ensure the project can be

applied. In situations, where required skills are unavailable locally, the team leader should explore opportunities for external support including benchmarking or partnering arrangements with other organizations, national or international assistance programmes and internet resources. The scope of the water safety plan should be defined by the team leader. The scope should describe which part of the water supply chain is involved and the general classes of hazards to be addressed.

The team should develop every steps of water safety plan in harmony with the steps outlined in other desirable features of water safety plan team include:

- Have the knowledge of water supply system and the types of drinking-water safety hazards to be anticipated;
- Have the authority to implement any necessary changes to ensure that safe water is produced;
- Inclusion of local staff whom are directly involved with the daily operations; and having sufficient people on the team to allow for a multidisciplinary approach, but not so many that the team has difficulty in making decisions. Team numbers will vary according to the size of the organization and complexity of process. The use of sub-teams is common and might for example include, water harvesting, water treatment and distribution operations.

The WSP team established and the level of engagement in this project in Iraq can be shown in Figure. 2.1 Below:

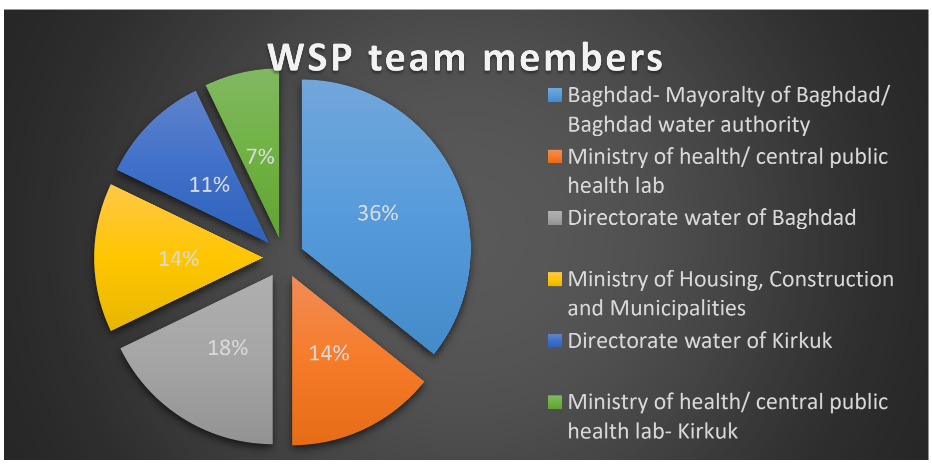


Figure. 2.1.: WSP team in Iraq and the level of engagement

Chapter 3
WATER SUPPLY DESCRIPTION

A description of the drinking-water system which is appropriate for large utilities and piped distribution systems, and individual domestic supplies. Evaluation of the existing infrastructure or of plans for new or upgrading of supplies is important to determine the weaknesses of the system. As drinking-water quality varies in the system, the assessment should object to determine whether the final quality of water delivered to the consumer meet the health-based targets or not.

3.1 Describe the Water Supply

The first step of the system assessment process is comprehensive description of the water supply from the source to the point of supply, covering the various types of source water and treatment processes. In terms of Iraq context, the focus on two main rivers (Tigris and Euphrates)

Surface water

- Description of water body type (e.g. river, reservoir, dam);
- Physical characteristics such as size, depth, thermal stratification and altitude;
- Flow and reliability of source water;
- Retention times;
- Water constituents (physical, chemical, microbial):
- Protection (e.g. enclosures, access);
- Recreational and other human activity and;
- Bulk water transport

Treatment systems

- Treatment processes (including optional processes);
- Equipment design;
- Monitoring equipment and automation;
- Water treatment chemicals used;
- Treatment efficiencies;
- Disinfection removals of pathogens and;
- Disinfection residual / contact period time.

Service reservoirs and distribution systems:

- Reservoir design;
- Retention times;
- Seasonal variations;
- Protection (e.g. covers, enclosures, access);

- o Distribution system design;
- o Hydraulic conditions (e.g. water age, pressures, flows);
- o Backflow protection and;
- o Disinfectant residuals.

A. Describe the Water Supply System and Water Quality Requirements

The first task of the WSP team is to describe the water supply system, through directing field investigations, and regular meeting with the WSP component. All the collected data of that system will be analyzed, documentation will be in two means using an Excel sheet as paperwork and by using the online application (Digital Monitoring System) with daily data collecting. This will provide sufficient data to identify where the system is vulnerable to hazardous events, relevant types of hazards, and control measures. The flow diagram will be developed through the online application which captures all the components of the water supply system in adequate detail which can validate the data in daily routine use and site field visits. Whenever the data collected where accurate then it will be easy to establish the risk assessment process, because it will automatically alert on the map or diagram where the weaknesses are. This DMS system will reduce time for collecting data and finalizing it to be ready for use in risk assessment activities

B. Recording information

Documentation of the water quality and of the system are important to ensure that hazards and risks are assessed and managed, the Digital monitoring system (DMS) can provide methodically to review and ensure the system is up to date and could check for accuracy by a site visit as well, in both way of documentation (paper or digital) as shown in Table 3.1. for system description

Description of the water supply is including:

- The source of water including the runoff or recharge processes;
- How water is stored or treated;
- What is added to water;
- How water is distributed;
- Quality of water specifications for each type of water produced;
- A system flow diagram; and
- An identification of the uses and users of water and availability of trained staff.

Table 3.1. Water system description form

Description of Current Water Supply system	
Name of project /Authority	
Project location - Government / District/Sub-district	
Design capacity (m³/day)	
Source of water	

no.	Names of sub-regions served			urban		rural	
				Share (m3 / day)	Number of beneficiaries	Share (m3 / day)	Number of beneficiaries
1							
2							
3							

Infrastructure details

Sources

	Name	Type	Reliability	Water quality issues	Capacity (m³/day)	Description	Notes
1							
2							

Treatment plant

No	Name	Process steps	Design capacity	Daily flow range	Chemical additives	percentage % of Water source to demand	Percentage% of average provided to day demand	Percentage% of supply to planed	Areas of supplies distribution	Notes
1										
2										

Distribution system

No	Pipe material	Average Age range	Approximate percentage % of total length	Areas where potential long detention periods could be expected	Areas where low water pressure (example < 12 m) could be expected during peak or other demand periods)	Notes
1						
2						

Reservoirs

no	Name	Type	Capacity (m³)	Notes
1				
2				

Chapter 4
UNDERSTANDING THE HAZARDS AND THREATS

Having the water supply described and formed flow diagrams to represent the supply in a logical and easily understood modality. The next step is to have a hazard analysis to establish what requires controlling to provide safe drinking-water.

4.1 Hazard Identification

Hazards may occur or be introduced throughout the water system, from catchment to consumer which can be evaluated throughout analyzing the data collected using the proposed DMS system. Effective risk management requires identification of all potential hazards, their sources, possible hazardous events and an assessment of the risk presented.
The hazard identification step needs the water safety plan team to consider all potential biological, physical, chemical and radiological hazards that could be related with the water supply. The team should start with the water sources, then progress through the validated flow diagram. At each step the objective is to identify what could happen to lead to water contamination; and the associated control measures for each hazard.

The water safety plan team should also consider influencing factors such as:

- Variations due to weather;
- Accidental or deliberate contamination;
- Pollution source control practices;
- Wastewater treatment processes;
- Drinking-water treatment processes;
- Receiving and storage practices;
- Sanitation and hygiene;
- Distribution maintenance and protection practices; and
- Intended consumer use.

4.1.1 Biological hazards

These hazards include testing the occurrence of pathogens such as:
- Bacteria;
- Viruses;
- Protozoa; and
- Helminths

Other, non-pathogenic organisms that influence the suitability of drinking-water should also be considered. It is not essential to eliminate completely microorganisms from drinking-water supply systems. What is required is to keep numbers of pathogens below levels of water quality standard to represent an acceptable level of risk as outlined in the water quality targets.

4.1.2 Chemical hazards

A chemical hazard can be measured any chemical agent that may compromise water safety or suitability, as shown in Table 4.1

Table 4.1: Examples of chemical hazards that may occur in drinking-water supply systems

Chemicals from watershed/ catchment	Chemicals from reservoir storage	Chemicals from water treatment processes	Chemicals from distribution
Nitrate Arsenic Fluoride Pesticides	Algal toxins Cleaners Liner chemicals Lubricants	Flocculants pH adjusters Disinfection by-products	Copper Lead Cleaners Petroleum

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4.2 Hazardous Events

Once hazards are listed, it is important to consider the matching events that lead to their entry into the drinking-water supply. These might be termed hazardous events or hazard causes. Hazardous events can cause contamination directly and indirectly.

For example, pathogens can pass in water supplies directly from faeces. However, cyanobacterial toxins result from growth of toxigenic cyanobacteria which are in turn promoted by a combination of factors. Therefore, issues, such as nutrients, which can promote cyanobacterial proliferation, can lead to water becoming unsafe and should be considered as contributory factors leading to the presence of a hazard. These contributory factors require managing as part of the water safety plan.

Box 4.1 illustrates how hazardous events in the catchment could be identified through performing a sanitary survey

A sanitary survey of the catchment area, the integrity of the infrastructure of the source headwork and the distribution system should be undertaken. Standardized forms for sanitary surveys and inspections are available in a number of documents linked to the WHO Guidelines for Drinking-water Quality (WHO, 1997; Howard, 2002). When performing a sanitary survey, it is important to ensure that pollutant source pathway- receptor relationships are borne in mind. Hazards in the environment do not automatically pose a risk to a water supply if there is no pathway by which they can enter the water supply. This is of particular importance for groundwater sources, where the hydrogeological environment and vulnerability of aquifers must be taken into account to ensure that a realistic assessment can be made of the likelihood of contamination and its severity. The potential for reduction in pathogen densities and chemical concentrations through attenuation, die-off and dilution should be assessed. Further details are provided in the monograph on the Protection of Groundwater for Public Health. The sanitary survey of water sources should result in a map that provides an indication of the location of major hazards and an indication of the likely risk posed.

Box 4.1: Identifying hazardous events in the catchment – performing a sanitary survey

For Iraq WSP, hazard identification including all type of hazards and hazardous events have recorded through risk assessment activities (office work and field visits) by the proficient team using endorsed documents forms and wide communication system as well as the online system to support the documentation and communication:

A. Hazard Identification and Determine Existing Control Measures

The role of online WSP system and DMS clearly shows the sufficient way in recording and identifying hazards and hazardous events with minimum time to get a required risk assessment and risk control. The new technique provides a daily status for all water system points, by recording accurate information about each hazard and existed correction measure.
The DMS can build a huge database to archive the required detail of likelihood and consequences which will lead to the best assessment and enable consistency.
This approach can provide a clear description of what went wrong and where in terms of hazards and hazardous events quickly, provide an easy assessment of risks with an explainable and comparable method. Several workshops and awareness sessions should be conducted to support staff to make them familiar with a new technique, as well as, to improve skills. See Table 4.2. Form of hazard identification

B. Prioritize Risks

All collected hazards and hazardous events analyses and prioritize according to (5X5) risk matrix see Table 4.3. Considering probability and consequences see Table 4.4 , from other side it will recorded through online and digital system, since, Online WSP system is applying the semi-quantitative

approach on a huge collected data on a daily basis, since, the most recorded hazards are mainly the turbidity and residual free chlorine from existing usual records.
This online system can control activities in an easy way, by gathering data automatically even when the documenting of activities is in a separate step with easy monitoring way for analysis purposes. These activities include:

- Identify all potential biological, physical and chemical hazards associated with each step in the drinking-water supply system that can affect the safety of the water (daily data from digital monitoring system).
- Identify all hazards and hazardous events that could result in the water supply being, or becoming, contaminated, compromised or interrupted (long term data, data from assessments team or others in digital monitoring system)
- Evaluate the risks identified at each point according to the flow approved diagram, (this evaluation could be done quickly through a digital monitoring system and figure out required control measure quickly.

Table 4.2. Form of hazard identification

Identify hazards and hazardous events					Measure the current control Identification and validation	
No	Process step location	Hazardous event (source of hazard)	Risk Description hazard (X) because of (Y)	Hazard type (biological, chemical, physical)	Existing control measures	Validation of existing control measures (sufficient or insufficient)
1						
2						

Table 4.3. Risk Matrix

	Consequences				
Probability	Insignificant or no impact -**Rating:1**	Minor Compliance Impact - **Rating:2**	Moderate aesthetic Impact - **Rating 3**	Major regulatory impact - **Rating 4**	Catastrophic public health impact **Rating:5**
Almost Certain /Once a day - **Rating 5**	5	10	15	20	25
Likely / Once a week - **Rating 4**	4	8	12	16	20
Moderate / once a month - **Rating 3**	3	6	9	12	15
Unlikely / once a year **Rating 2**	2	4	6	8	10
Rare once every 5 years -**Rating 1**	1	2	3	4	5
Risk score	**≤ 6**	**6.-9**		**10.-14**	**≥ 15**
Risk rating	**Low**	**Medium**		**High**	**Very high**

Table 4.4 probability and consequences indications

Probability Score	indication		Consequences Score	indication
Almost Certain /Once a day - **Rating 5**	daily happened		Insignificant or no impact -**Rating:1**	water lack or not affecting public health
Likely / Once a week - **Rating 4**	weekly happened		Minor Compliance Impact - **Rating:2**	short term hazards not affecting public health or lack of water
Moderate / once a month - **Rating 3**	monthly happened		Moderate aesthetic Impact - **Rating 3**	long term hazards not affecting public health
Unlikely / once a year **Rating 2**	yearly happened		Major regulatory impact - **Rating 4**	hazards might cause diseases
Rare once every 5 years -**Rating 1**	every 5 years happened		Catastrophic public health impact **Rating:5**	long term hazards serious public health, affecting general health leading to death

C. Risk Assessment

Through collecting required information and conduct field visits team can identify and record the most hazards and record them with sufficient way along with online system recording below is the endorsed form (See table 4.5.) and online system form shown the significant risks which is same table from the online system.

The below table extracted from the online system will be one of the resources to feed the auditors or risk assessment team where they can use their experience and knowledge of the system to give the best recommendations and can support for good practices

Table 4.5 Risk assessment form

Identify hazards and hazardous events				
No	**Process step location**	**Hazardous event (source of hazard)**	**Risk Description hazard (X) because of (Y)**	**Hazard type (biological, chemical, physical)**
1				
2				

Chapter 5
CONTROL MEASURES AND PRIORITIES

This chapter summaries the control measures for catchment protection, water treatment. All significant hazards in the water supply process, identified during the hazard analysis need to be identified as being controlled, or possibly controlled, by some mitigating process

5.1 Determine Control Measures

Control Measures are the steps that directly affect water quality and, ensure that water constantly meets health-based targets. The measures include actions, activities and processes applied to avoid or minimize hazards occurring
The control measures (often referred to as 'barriers') will already be in place where the measures should be assessed to determine if they meet current (i.e. health-based target) requirements. Control measures are identified by considering the hazardous events that can cause contamination of water, both directly and indirectly, and the activities that can mitigate the risks from those events. Control measures need to be identified at the point of contamination (where the hazardous event occurs) as well as downstream so that the effect of multiple barriers can be assessed together.
Flow diagrams are mainly valuable to support the identification of control measures. This is because it simplifies the task theoretically. There are hundreds of control measures for a large system, or for a water safety plan covering many small systems. For instance, control measures would include every point-of-use water treatment unit or each backflow prevention valve. To make the water safety plan simpler to develop, control measures that are alike can be represented on a flow diagram as one process step. The main result of rolling up groups of control measures into single process steps is that comparatively few key process steps emerge. In some case studies of water safety planning these steps on the flow diagram are given the name Critical Control Points.

The control measures must apply to the entire water supply process control measures for pathogenic and chemical hazards include those that relate to source protection and engineered assets. Including drinking-water treatment plants, disinfection plants, storage reservoirs and backflow protection. Most control measures are non-engineered, and, for example, many standard operating procedures include water safety considerations. The work practice defined in such a standard operating procedure which considered a barrier to contamination and, therefore, a control measure and form an integral part of a water safety plan.

The protection programmes are likely to include the different control measures that applied. In many cases, actions to ensure the barriers are established and maintained may not be the sole responsibility of the water supplier but may require multi-agency action where in our case would be the Ministry of Municipality and Ministry of Health and Environment.

5.1.1 Resource and source protection

Many benefits can be considered when having a catchment management. By reducing the water contamination, the amount of treatment and quantity of chemicals needed. This will lead to reduce the production of treatment by-products and minimize operational costs. Examples of source protection are given in Box 5.1.

Effective resource and source protection include the following elements:

- Developing and implementing a catchment management plan, which includes control measures to protect surface sources;
- Ensuring that planning regulations include protection of water resources (land use planning and water shed management) from potentially polluting activities and are enforced; and
- Promoting awareness in the community of the impact of human activities on water quality.

Box 5.1: Examples of source water, storage and extraction control measures

Source water and catchments

- Designated and limited uses
- Registration of chemicals used in catchments
- Specific protective requirements (e.g. containment) for chemical industry or refueling stations
- Reservoir mixing/desertification to reduce growths of cyanobacteria, anoxic hypolimnion and solubilization of sedimentary manganese and iron
- pH adjustment of reservoir water
- Control of human activities within catchment boundaries
- Control of wastewater effluents
- Land use planning procedures, use of planning and environmental regulations to regulate potential water polluting developments
- Regular inspections of catchment areas
- Diversion of local storm water flows
- Protection of waterways
- Runoff interception
- Security to prevent sabotage and tampering

Water extraction and storage systems

- Use of available water storage during and after periods of heavy rainfall
- Appropriate location and protection of intake
- Appropriate choice of off-take depth from reservoirs
- Water storage systems to maximize retention times
- Roofed storages and reservoirs with appropriate storm water collection and drainage
- Securing tanks from access by animals
- Security to prevent unauthorized access, sabotage and tapping and tampering

5.1.2 Water treatment

The next important barriers to water contamination of the drinking-water system is the water treatment processes. Source waters of very high quality may only require watershed protection and disinfection. Control measures may include pre-treatment, coagulation flocculation-settling, filtration and disinfection, examples are given in Box 5.2

Box 5.2: Examples of treatment control measures

Water treatment system

- Coagulation/flocculation and sedimentation
- Alternative treatment
- Use of approved water treatment chemicals and materials
- Control of water treatment chemicals
- Process controllability of equipment
- Availability of backup systems

Water treatment process optimization including:

- chemical dosing
- filter backwashing
- flow rate
- minor infrastructure modifications
- Use of tank storage in periods of poor-quality raw water
- Maintaining security to prevent sabotage and illegal tampering

The pretreatment processes that required in most cases are includes roughing filters, micro strainers, off-stream storage and bank-side filtration. Pretreatment selections may be compatible with a variety of treatment processes ranging in complexity from simple disinfection to membrane processes. The advantages of pretreatment processes is by reducing, or steadying the microbial load to the treatment processes.

The particles, including microorganisms (bacteria, viruses and protozoa) can be removed through coagulation, flocculation, sedimentation (or flotation) and filtration processes. It is important that processes are optimized and controlled to achieve consistent and reliable performance. Chemical coagulation is the most important step in determining the removal efficiency of coagulation/flocculation/clarification processes. It also directly affects the removal efficiency of granular media filtration units and has indirect influences on the efficiency of the disinfection process. While it is unlikely that the coagulation process itself introduces any new microbial hazard to finished water, a failure or inadequacy in the coagulation process could result in an increased microbial load entering drinking-water distribution.

The filtration processes are used in drinking-water treatment, including granular, slow sand, pre-coat and membrane (microfiltration, ultrafiltration, nano-filtration and reverse osmosis) filtration. Suitable design and operation, filtration is important and effective barrier for microbial pathogens and may in some cases be the only treatment barrier (for example for removing Cryptosporidium oocysts by direct filtration when chlorine is used as the sole disinfectant).

The disinfection process is an essential element for most treatment systems to achieve the required level of microbial risk reduction. Valuation of the level of microbial inactivation through the application of disinfection processes and the type of process that required based on the types of contamination (product of disinfectant concentration and contact time) for a particular pH and temperature required for the more resistant microbial pathogens ensures that other more sensitive microbes are also effectively controlled.

A. Identify the required controls

1- By determining the existing control measures for each identified hazard and hazardous events;
2- By documenting and addressing the required missing controls;
3- Validate the effectiveness of the controls;
4- By obtaining evidence on the performance of control measures; and
5- By facilitating the operational monitoring.

Both validation and operation monitoring are done by the digitalized monitoring system to show the validation of control measures is operated effectively, effectively and more sustainability. Moreover, each control measure will be recorded according to the head of Water plant for sufficient monitoring. Also, it will provide an up to date archive to demonstrate the performance of control under normal and exceptional circumstances.

B. Identifying Additional or Improved Control Measures

The WSP team must check if the existing controls are effective depending on using the Digital Monitoring System (DMS) from operational monitoring of data collected and field's visits. The online WSP can help the team to follow up the effectiveness of each control measure in the daily manner (up to date follow up) along with the possibility of daily analysis of the collected data, since, all this information has to be recorded against the relevant hazards and hazardous events in the digital monitoring system (DMS). Although, corrective measures should be documented on the paperwork (excel sheet form) for records and archiving. In case a need to modify the system, these **control measure** options will be useful to ascertain suitable technologies and interventions for the situation. All this information available and accessible in the database of the DMS.

The automated system designed to control regular operational works and during the emergency context in the same way on daily monitoring, and then, able to predetermine water quality incident and during the application of emergency response plans.

"Control measures ('barriers' or 'mitigation measures'): are steps in the drinking-water supply that directly affect drinking-water quality and ensure water consistently meet water quality targets. These lists of activities and processes applied to reduce or mitigate risks."

Control measures may take the form of:

- Prevent contaminants (hazards) gaining access to water;
- Remove hazards from water;
- Inactivate pathogens in water; and
- Maintain the quality of water during distribution.

By gathering the data and provide strong documentation for the corrective measures with the hazards and hazardous events, to document more information side by side with daily collected data from the online system, since, this application designed to facilitate and collect all details for each caseload and each hazard.

C. Re-assess the Risks

In the view to the risk assessment concept, the risks can be recalculated in terms of likelihood and consequences with the effectiveness of each control, as well as the potential fail or be ineffective over a short period of time which can clearly be shown through the digital monitoring system (DMS)

D. Prioritize all Identified Risks

The online and digitalized system designed to provide the ability to prioritize the risks automatically depending on risk scoring from the risk matrix and the probability of impact on the capacity of the system to deliver safely managed water.

From below table (Table 5.1), risk scoring form is calculated by multiplying 'Likelihood' by 'consequences', the results recorded and those hazardous events with scores at the critical limit or above are investigated to reduce their risks.

Table 5.1. Risk scoring form

Risk assessment			
Likelihood (1,2,3,4,5)	**Consequence (1,2,3,4,5)**	**Score**	**Risk rating (before consideration of controls)**

Risk Assessment Methodology:

By using risk matrix, likelihood and consequences to find risk score or rating the risk which might be automatically through the digital monitoring system, see Table 5.2. for risk scoring

Table 5.2. Risk scoring and risk Rating

***Risk Score**= multiplying likelihood by consequences*			
	Risk Score	**Risk Rating**	
	≤ 6	**Low**	
	6 - 9	**Medium**	
	10 - 14	**High**	
	≥ 15	**Very high**	

Probability	**Consequences**
Almost Certain /Once a day - **Rating 5**	Insignificant or no impact -**Rating:1**
Likely / Once a week - **Rating 4**	Minor Compliance Impact - **Rating:2**
Moderate / once a month - **Rating 3**	Moderate aesthetic Impact - **Rating 3**
Unlikely / once a year **Rating 2**	Major regulatory impact - **Rating 4**
Rare once every 5 years -**Rating 1**	Catastrophic public health impact **Rating:5**

Chapter 6
DEVELOPMENT, IMPLEMENTATION AND MAINTENANCE OF UPGRADED PLAN

Improvement or upgrade Implementation and Maintenance of Improvement/ Upgraded plan will be conducted after identifying significant risks and demonstrate the ineffective existing controls to provide a detailed description for the implementation of operational processes and process control.

The formulated WSP team (Working in groups) have the capacity to prepare and formalize development plan or any appropriate corrective action linked to each correction measure and they are responsible to prepare any other requirements or documents (see Table 6.1) to apply recommended activity depending on their experience and knowledge, considering the below parameters:

- Specifications to be undertaken;
- Responsible party;
- Due date;
- Budget;
- Resource constraints (financial, human); and
- Short, medium, or long-term priorities.

The new technique of close monitoring through the digital monitoring system and new WSP guideline in daily basis could discover and control the new risk.

Table 6.1. Improvement Plan

IMPROVEMENT PLAN TABLE									
No.	Process step location	Hazardous event (source of hazard)	Specific improvement action or Additional requirements for risk control (corrective action)	priority or score of risk	Responsible party	Estimated budget	Funding source	Due date	% of achievement
1									
2									

Chapter 7
LIMITS AND MONITORING (OPERATIONAL MONITORING)

The operational limit (often defined as an alert limit or an action limit) is a standard that indicates whether the control measure is functioning as designed. By exceeding the operational limit indicates that action is required to prevent the control measure moving out of compliance. The term critical limit is often in some water safety plans to single out operational limits linked directly to absolute acceptability in terms of water safety. The process of monitoring is important by conducting a planned series of explanations or measurements of operational and/or critical limits to assess whether the components of the water supply are operating properly.

The operational limit should be defined for each control measure which, as part of the overall process train, leads to the supply of water that meets the intended use (including the health targets). Though, since it is rarely practical to measure the concentration of hazards directly, some other means of control measure act needs to be identified and becomes the target of monitoring. Therefore, a relationship between control measure performance, as determined by measurable parameters, and hazard control performance needs to be established. This relationship can be established using theoretical and/or empirical studies. In general, long-term performance data, design specifications and objective scientific.

The following criteria should be taken, and it is possible to define operational limits for control measures:

- Limits for operational acceptability can be defined;
- These limits can be monitored, either directly or indirectly (e.g., through surrogates);
- A pre-determined corrective action (response) can be enacted when deviations are detected by monitoring;
- The corrective action will protect water safety by bringing the control measure back into specifications by enhancing the barrier or by implementing additional control measures; and
- The process of detection of the deviation and completion of the corrective action can be completed in adequate timeframe to maintain water safety.

A. Monitoring Parameters

The selection of parameters for operational monitoring is very important because it should reflect the effectiveness of each control measure, provide a timely indication of performance, and be readily measured and provide opportunity for an appropriate response. Some water quality characteristics can be the main indicators for characteristics for which testing is more difficult or expensive. For example, conductivity test is widely used as indicator for TDS.

B. Operational Limits

The operational limits should be defined by the water safety plan team for each control measure based on operational parameters such as chlorine residuals, pH and turbidity level, or observable factors.
Important note that the limits need to be directly or indirectly measurable. Current knowledge and expertise, including water quality standards and technical data, as well as locally derived historical data, can be used as a guide to establish the limits. The established operational limits might be set for the system to run at optimal performance while the term critical limits might be applied when corrective actions are required to prevent or reduce the impact of expected hazards on the safety and quality of the water.
Limits can be classified as upper limits, lower limits, a range or an envelope of performance measures. They are usually indicators for which results can be readily interpreted at the time of monitoring and where action can be taken in response to a deviation in time to prevent unsafe water being supplied.

C. Monitoring

The main questions of the monitoring should consider the ‘what’, ‘how’, ‘when’ and ‘who’ cause the impacts on the system. In most cases, tedious monitoring will be based on simple substitute observations or tests, such as turbidity or structural integrity, rather than complex microbial or chemical tests. The complex tests are generally applied as part of validation and verification activities rather than in monitoring operational or critical limits.

When monitoring results indicate that an operational or critical limit has been exceeded, then there is the potential for water to be, or to become, unsafe. The objective of monitoring process is to monitor control measures in a timely manner to prevent the supply of any potentially unsafe water. As essential component of monitoring process is the monitoring plan should be prepared and a record of all monitoring should to be maintained.

Monitoring plan

The plans and procedures for monitoring the various aspects of water supply system should be documented. Monitoring plans should include the following information:

- Parameters to be monitored;

- Sampling location and frequency;
- Sampling needs and equipment;
- Schedules for sampling;
- Methods for quality assurance and validation of the sampling results;
- Requirements for checking and interpreting the results;
- Responsibilities and necessary qualifications of staff;
- Requirements for documentation and management of records, including how monitoring results will be recorded and stored; and
- Requirements for reporting and communication of results.

Iraq WSP - Validation and Verification Stream

7.1 Define monitoring of the control measures (Validation)

After determining the control measures for each hazard, the best methodology to monitor these measures at the designed online digital monitoring system (DMS), since, there is a daily and routine automatic system which shows the status, records, and communications among all parties. The monitoring should be including the following monitoring factors:

A. Operational monitoring

The formulated working groups are collecting the required information according to the established procedures. For Operational monitoring and validation and to make sure that the control is functioning and operational.

All these actions can be documented by the online digital monitoring system (DMS) as well as the management procedures through the endorsed official form (see Table 7.1.). In case the operational targets are not met, the monitoring system can display the necessary corrective actions accordingly through the tables or online digital system, depending on data from WSP inspectors or the delegated technical staff.

B. Establish corrective action for deviations that may occur

The online digital monitoring system designed to monitor all control points to support risk management despite the type or number of control measures and can clearly display which one is effective or not, even if a deviation is detected, actions can be taken in a timely manner.

- All water supply system is under monitoring by the designed digital system since all daily inputs can be covered from all users around all over the supply system;
- The online digitalized system designed to reduce the lead time for monitoring to a minimum;
- Monitoring is done through the operational and external staff, while the information can be gathered directly;
- An easy methodology for analysis; and
- Easy to get the best recommendation for action.

This modality of monitoring data in the online DMS provides comprehensive feedback on how water supply system is operating with easy frequently assessment on daily basis through delegated local staff who change his attitude to monitor in a certain way.

Table 7.1. Monitoring and Validation form

Monitoring and Validation											
No.	Process step location	Hazardous event (source of hazard)	Specific improvement action or Additional requirements for risk control (corrective action)	priority or score of risk	Monitoring by	Date of Monitoring	How to be monitored	Operational Range and Critical Limits	Status update Audit procedures and validation	Required action if the status is not sufficient	Notes
1											
2											

7.2 Verify the Effectiveness of the WSP (verification)

Verification is the formal and systematic process of the WSP ensures that roles and responsibilities are outlined, personnel assigned, and it is working properly through three objectives:

- By building a body of evidence that water produced by water supply system is compliant with water quality objectives.
- By confirming WSP is being implemented in practice as it has been designed.
- By confirming the critical limits and other core values are appropriate to control the identified risks, so that, the system can produce water according to proposed uses.

In this online digital system, it will be easy to get information or routine data, such as, testing results, status of water treatment, corrective actions and other data about most locations, in addition to the regular monitoring activities undertaken for each operational process in the supply system, for all that, the formulated technical working groups and WSP team can use these data with procedures to audit processes and practices of water supply and all the distribution system for best verification.

Three key indicators provide solid evidence in terms of the functionality of WSP

- Compliance monitoring;
- Internal and external auditing of operational activities; and
- Consumer satisfaction.

A. Compliance monitoring

The designed digital monitoring system foster clear monitoring of the performance against standard limits and the required corrective actions which are led to a good understanding of the causes of unexpected results.

According to this system, the verification monitoring could be, once per each working day, with up to date data from the collected database see Table 7.2

B. Internal and external auditing of operational activities

In general, auditing is a type of verification support to maintain the practical implementation of WSP, ensuring that water quality and risks are controlled, hence, the auditing have both an assessment and compliance checking role.

Audits may involve internal and external review by regulatory authorities or by qualified independent auditors.

According to this digital system, auditing can be:

- Internal auditing through online digital WSP system which can be on a daily or even monthly basis.
- External auditing via third party conducted every six months or as required and with the online digital databases.

C. Consumer Level of Satisfaction

Part of verification is consumers' satisfaction, according to the online digital system, it is flexible to give consumers or beneficiaries the chance to share their feedback (level of satisfaction) or even as a third independent party on monitoring especially on the water network at the household level.

Table 7.2. Verification Monitoring form

Verification Monitoring form										
No.	Process step location	Hazardous event (source of hazard)	Specific improvement action or Additional requirements for risk control (corrective action)	priority or score of risk	How to be monitored	Operational Range and Critical Limits	verified by	date of verification	Outcome of verification	Notes
1										
2										

Chapter 8

MANAGEMENT PROCEDURES

When the monitoring process notices that a process is operating outside the specifications of the critical or operational limits, there is a need to act to restore the operation by correcting the deviation. The main important element of a water safety is the development of corrective actions which identify the specific operational response required following specific deviations from the set limits (operational and/or critical).

8.1 Corrective Actions and Incident Response

A Corrective Action is defined as the action that should be taken when the results of monitoring indicate a deviation from an operational or critical limit.
The range of corrective actions can be varied but, in an ideal system, the ability to change temporarily to alternative water sources is one of the most useful. However, the use of backup disinfection plants or spot dosing may be used to correct disinfection system disappointment within the water supply system. By relying on the contingency is available and promptly applied in the event of a deviation outside an operational or critical limit, safety and security of supply can be maintained.
It is important to detect the deviation through monitoring and respond through corrective action to prevent contaminated water being supplied to consumers, therefore, timing of response is a critical consideration. For some control measures, such as chlorination, the monitoring may need to be on-line and may require immediate corrective action in response to any deviation.

Corrective activity might be introduced in response to deviations arising from events like:

- Unusual taste, odor or appearance of water;
- Non-compliance with operational monitoring criteria;
- Inadequate performance of a sewage treatment plant discharging to water source;
- Notification of chance events;
- Discharge of a hazardous substance into water source;
- Floods and mixing fresh water with sewerage;

Corrective actions typically comprise:

- Accountability and contact details for key personnel;
- Clear description of the actions required in the event of a deviation;
- Location and identity of the standard operating procedures (SOP) and required equipment;
- Location of backup equipment;
- Relevant logistical and technical information.

8.2 Emergency Management Procedures

For exceptional results that might arise throughout the application of water safety plan for which no corrective action taking into consideration. Thus, it's necessary to develop corrective actions without warning. While it is not possible to have specific and detailed corrective actions in place to respond to such likely situations, it is essential to have in place a generic emergency response plan for unpredictable events like cholera outbreak in potential high-risk communities since this disease is considered as an endemic in Iraq since 1966.

Developed emergency preparation and response plan would not have specific definitions of the operational and critical limits that, if deviated from, activate a corrective action. Rather, the plan would include a protocol for situation assessment and the declaration of situations that require activation of the emergency response plan. This would include personal answerabilities and categorical selection criteria. The selection criteria may include:

- Time to effect;
- Population affected; and
- Nature of the suspected hazard.

Experience, judgement and skills of the personnel operating and managing the drinking-water supply systems are the main factors for successful emergency responses. However, the general activities that are common to many assumed contamination events can be combined within the emergency response plan. For instance, for piped water systems, emergency flushing standard operating procedures can be prepared, and tested, for use if contaminated water needs to be flushed from a piped system. Similarly, standard operating procedures (SOP) for rapidly changing or by-passing reservoirs can be prepared, tested and incorporated. The development of such a ‘toolkit’ of supporting material limits the likelihood of error and speed up responses during emergency response situations.

The emergency response plans can be very comprehensive and can include major disasters (such as earthquakes, floods, and cholera outbreak), damage to treatment plant and distribution system, and human actions (civil unrest and conflicts). Emergency response plans should clearly state the roles and responsibilities for coordination mechanism and measures to be taken, a communication plan to alert and inform users of the supply and plans for providing and distributing emergency supplies of water which is the DMS online system that going to play that role. Emergency response plans should be developed in discussion with relevant represented authorities, other key agencies and should be consistent with national and local emergency response arrangements. Key areas to be addressed during emergency response plan include:

- Response actions, including increased monitoring;
- Roles and responsibilities and authorities internal and external;
- Plans for emergency water supplies;
- Communication protocols and strategies, including notification procedures (internal, coordination body, media and public awareness); and
- Appropriate and efficient mechanisms for increased public health surveillance.

During the emergency events where water contamination occurs in the supply, it is necessary either to modify the treatment of existing sources or temporarily to use alternative sources of water. It may be necessary to increase disinfection dosing at source or to re-chlorinate during distribution.

General guidance of concerning emergencies in which chemicals cause massive contamination of the supply, either caused by accident of careful action. The guideline values suggested in the Guidelines for Drinking-water Quality relevant to a certain level of exposure that is regarded as tolerable throughout life; acute toxic effects are not normally considered. The timing for the responses during exposure to a chemical far in excess of the guideline value would be toxicologically detrimental will depend upon factors that vary from contaminant to contaminant. In an emergency context, the public health authorities should be consulted about appropriate action.

After any emergency event discovered, an investigation should be undertaken, and all involved stakeholders should be debriefed to discuss performance and address any issues or concerns. The investigation should consider factors such as:

- What was the initiating cause of the problem?
- How the problem was first identified or recognized?
- What were the most essential actions required?
- What communication problems arose and how were they addressed?
- What were the immediate and longer-term consequences?
- How well did the emergency response plan functioning?

Suitable documentation and reporting of the emergency should also be established which is in our case the online system DMS. The organization should learn as much as possible from the emergency to improve preparedness and planning for future emergencies. Review of the emergency response may indicate necessary amendments to existing protocols.

Establishing clear procedures, accountabilities and equipment for the sampling and storing water in the event of an emergency can be valuable for follow up epidemiological or other investigations, and the sampling and storage of water from early on during a suspected emergency should be part of the response plan.

For Iraq Caseload

Prepare Management Procedures (Documentation and communication)

- **Documentation**

Setting up the required documents, procedures and develop the documentation managed by staff with acceptable level of expertise for each activity, as possible, this approach could enhance the ownership of local staff and make the implementation of these procedures gone smoothly.

Management procedures include:

1- **Procedures in normal operating conditions:** The actions should be taken during normal operational conditions; from another side it includes all details of steps to follow in specific incident situations where a loss of control of the system may occur.
   a. Procedures during normal operation, principally operational monitoring with defined roles and responsibilities;
   b. Procedures for corrective actions following incidents, including defined roles and responsibilities and location of any needed backup equipment.

2- **Management procedures in emergency conditions:** which include responsibilities and alternative water service providers.

The designed Digital Monitoring System (DMS) can provide wide range of database to be used to find best practice and an easy way to share and support any required information and knowledge among the staff, since, management procedures could be documented alongside system assessment, monitoring plans, and communication procedures which is required to ensure safe operation for the system.

Documentation of developing the corrective actions is essential to identify the specific required operational response considering all deviations from the set limits as well as, all aspects of WSP are essential to be documented clearly.

Through the digital system, the collected data and management local staff can ensure procedures through up to date system and can keep operation and management staff connected and involved, so that, it is easy to do the right thing

This digital system by an efficient, regular review and updating cycle can provide adequate resources of information to ensure keep forward, at the same time, digital monitoring system was designed to detect if the process is operating outside of the specifications of the critical or operational limits, and then, can provide the required documentation to correct this deviation, hence, all local staff can extract the required documents for his use accordingly.

- **Communications:**

The digital system designed for an online technique which is an effective communication strategy, play a strong and essential role for mitigating risk. The communication strategy in the DMS system includes, the online digital system gives an easy and quick methodology for the advice of any significant incidents in the produced drinking water at source. This including notification of the public health authority, the digital system allows open communications and continuous networking among all stakeholders (service providers and surveillance) during operating and monitoring for water supply system.

On the other side, the DMS system provides useful and readable source of information available to help consumers to understand procedure of water production and its safety, through website. In phase II, there is a possibility to develop the digitalized system receiving and actively addressing community feedback and complaints, where this modality will enable the DMS enhance more transparency towards the Iraqi population.

- **Communication during the emergency context**

The digitalized system designed to involve all staff responses which is useful to assess whether the current procedures of treating water are adequate or not to be able to address any deviation of the water safety.

For each emergency caseload, the digitalized system designed to provide a wide range of data in short time to support in the required investigations and review the root cause of each emergency and the response, so that, the amendments of risk assessments or the overall WSP went smoothly and efficiently.

All collected data could be helpful for the WSP team to prepare the appropriate emergency response plan for each caseload, as they are accountable and responsible to ensure emergency plans are operational for each caseload and include it in this digital system.

Chapter 9
SUPPORTING PROGRAMMES

Supporting programmes are actions that ensure the operating environment, the equipment used and the authorized people do not become an additional source of potential hazards to the drinking-water supply.

Multiple activities are important to ensure water safety, but do not affect water quality directly, supporting programmes fall into this category. These activities should incorporate the principles of good process control that underpin the water safety plan. Factors of good operating, management and hygienic practices are essential elements for supporting programmes. These are often captured within standard operating procedures (SOPs) or system operating rules which include, but not limited to:

- Hygienic working practices documented in maintenance SOPs;
- Training and competency of local staff involved in water supply;
- Tools for managing the action of staff, such as quality assurance systems;
- Defining commitment of the stakeholders at all levels, to the provision of safe water;
- Community awareness and their engagement in the improvement of water quality;
- Calibration of monitoring equipment; and
- Records keeping.

Supporting programmes could exactly involve:

- Controlling the authorized officers that have direct work at the water treatment plants, catchments and reservoirs in order to prevent the accessibility and responsibility for any issue that might occur for the water safety;

- Development of verification protocols for the use of water purification chemicals and materials used in water supply, for instance to ensure use of the service providers that participate in international quality assurance programmes;
- Training and educational programmes for the local staff involved in activities that could significantly affect water quality. Training should be implemented as part of induction programmes and updated frequently.

For Iraq Caseload

Develop supporting programs (skills, knowledge and capacity building)

Supporting programmes designed to do a good job and they can range from research and development and individual training through to upgrading of equipment and operating hygienically and can make the difference between WSP success or failure, as often the sustainability depends not on following the step-by-step approach, but rather to develop the right support for people in terms of their roles of responsibilities.

The WSP of the digitalized monitoring system has open communication and up to date monitoring, which can help them to:

- Find any needed knowledge (along with training and awareness);
- Required calibration (critical limit monitoring);
- The maintenance processes schedule (Preventive maintenance);
- Find any hazards or risks from water produced.

DMS also designed to provide guidelines, required documents (like SOPs, standards), clearing the limits and wide accurate recording for all users.

All these activities and more are supporting the development of people's skills and knowledge, commitment to the WSP approach, and capacity to manage systems to deliver safe water in a daily manner. More indirectly support, like, improve equipment and quality control in laboratories, and increase the understanding between laboratories and water service providers. Other activities, continuing education courses, calibration of equipment, preventive maintenance, hygiene, and sanitation as well as legal aspects. Finally, the supporting programs and activities that would be part of the WSP approach are going to embed in the operations of the water utilities.

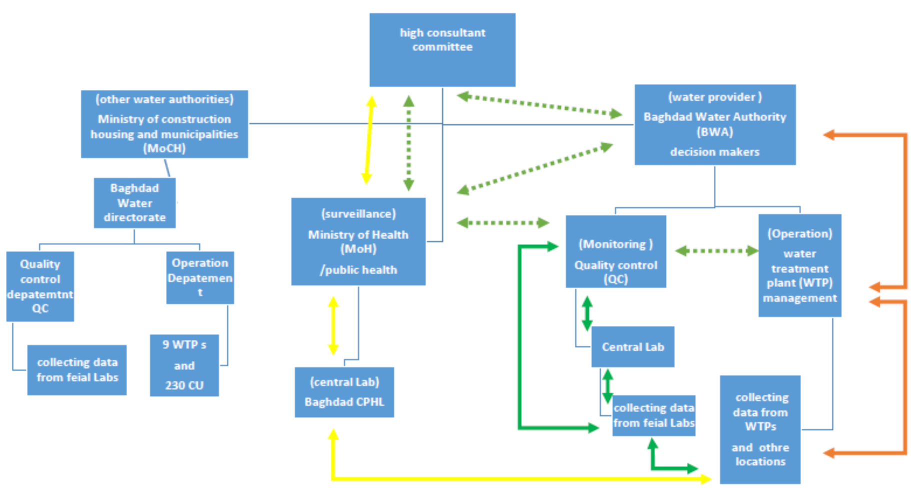
Chapter 10
DOCUMENTATION AND RECORD KEEPING

The documentation of the WSP of the system could be summarized in this chapter and outlines the record keeping that will form essential element of its implementation. Documentation and records keeping are important for reviewing the adequacy of water safety plan and the adherence of the water supply system to the plan.

10.1 Documenting the Water Safety Plan

The below flow chart represents the procedure that DMS system used in order to share information and input the date collected from the water system among all the counter pares whom involved in drinking water production and surveillance in Iraq. Figure 10.1

Data flow chart in water safety monitoring system



Operations Data	
Monitoring Data	
Surveillance Data	
Sharing information among decision makers	

Figure 10.1 Data sharing and data following

10.2 Record Keeping and Documentation

Important component that make the water safety plan concrete is the requirement of a range of records which form part of water safety plan setting up and implementation process as well as monitoring and any necessary corrective actions taken, incident response records, validation and verification. These can fundamentally be divided into four types of records:

- Support documentation for developing water safety plan;
- Records generated from water safety plan system;
- Documentation of methods and procedures used; and
- Records for local staff training programmes

The collected date from the Water Safety Plan system should be kept demonstrating the adherence of the system to water safety plan. By following records generated from water safety plan system, delegated operator or manager can become aware that a process is impending its operational or critical limit. Reviewing the date collected can be instrumental in identifying trends and in making operational adjustments. Periodical review of water safety plan records is essential so trends identified and appropriate actions including: samples collecting, testing procedures, results reports and etc. Which are decided upon and implemented.

Documentation and records systems should be kept simple and emphasis whenever possible. The level of details in the documentation of procedures should be sufficient to provide assurance of operational control when linked to suitable qualified and competent operator.

The process of documentation, records keeping, and reporting of incidents/emergencies should be established to periodically review and, where necessary, revise documents to reflect changing in the context, while documents should be assembled in a manner that will enable any necessary modifications shall be made easily. A document control system should be developed to ensure that current versions are in use and obsolete documents are discarded.

Lesson learnt from any incident should be taken in order to improve preparedness and planning for future events. Review of an incident may indicate necessary amendments to existing protocols and may suggest that upgrading of water system is required.

Plan and carry out a periodic review of the WSP (Ensuring)

The digitalized online monitoring system (DMS) provides a sufficient regular review to ensure that each new risk threatening the production and distribution are regularly assessed and addressed, hence, it has acceptable regularly review to WSP through analyzing the collected data during the monitoring process in daily basis which can be used in overall review and learn from experiences, however, periodically overall review should be made in several cases like; in six months or over a year and following an emergency context or incident for any problem within water supply chain.

Additionally, the risk assessment process and new corrective actions help to improve/upgrade plan, as well as, revising the WSP generally and applying new procedures.

With this strategy of updating (online digitalized system), the WSP is up to date all time, since, all collected data are up to date from catchment areas ending up to consumers, records any new change among local staff or contact information and any updating or revising in process or risk assessment is regularly updated.

The systematic review of monitoring results in the digitalized system over an extended period (typically 12 months) is essential to evaluate whether the existing system management practices is effective and efficient to reduce risks and identify opportunities for improvement, generally, it is needed:

- To assess overall performance against regulatory requirements or agreed levels of service;
- To identify emerging problems;
- To assist in determining priorities for improving the quality of drinking water.

The evaluation mechanisms for results is harmonizing with the digitalized system, since all roles, responsibilities, accountabilities and reporting requirements have been defined enhanced the interpretation of data sets including the statistical evaluation of results and graphs or trend charts.

Evaluation of results could be reported internally to senior executive and externally disseminated to consumers, stakeholders and authorities through the online digitalized monitoring system, since, data are regularly reviewed, and the improvements have made in response to identified problems will definitely improve confidence among consumer.

Periodic auditing of all aspects of the drinking water quality management system is essential to confirm that activities are being carried out in accordance with defined requirements and feeding the required outcomes.

Audits are important for maintaining a functional drinking water quality management system and identifying areas for improvement. Internal audits will involve trained staff and should include a review of the management system and associated with the operational procedures, monitoring programs, and the generated records, the main objective is to ensure the system is being implemented correctly and effectively. Moreover, external auditing should be carried out by an independent third party since these audits should focus on confirming the implementation and results of internal audits.

External audits could be conducted on:

- The management system;
- Operational activities;
- Drinking water quality performance;
- The effectiveness of incident and emergency response or other specific aspects of drinking water quality management.

Audit results should be documented and communicated to management and the local staff responsible for the department or function being audited. Results of audits should also be considered as part of the review by a senior executive.

Chapter 11
REVISE THE WSP FOLLOWING AN INCIDENT (INCIDENTS AND COMPREHENSIVE REVIEW)

Revision and evaluation for WSP should be carried out by the WSP team in periodically or following an incident, emergency or avoided incident to stand on the mechanism of a WSP that should be updated and identify what is needed, but first, the cause of the incident should be determined and identify the best recommendations then revisions shall be applied to the WSP regardless new hazard/hazardous event is identified.

One of the most important benefits of reviewing the WSP is the mitigating the likelihood of the incident being repeated and determine whether the actual response was the best possible and better protection of the public health, (lessons learned from the incident rather than file the records).

A comprehensive and transparent review for WSP should be done to stand on the adequacy of the utility’s response. Also, enrolling the lessons learned into WSP documentation and procedures, to ensure that the WSP can cover emerging hazards and issues.

The digital system provides a wide background of information and database to get enough information about each incident or even hazards to study each case and find the best recommendations.

Chapter 12
VALIDATION AND VERIFICATION OF WSP

12.1 Validation

Validation involves finding evidence that the elements of the water safety plan are effective.
The validation of WSP processes should be targeted at the assessment of the scientific and technical inputs into the water safety plan. Validation should confirm that information supporting the plan is accurate and the elements of the water safety plan will be effective which then will be allowing conformity with health-based targets and public health policy. Process validation is essential to demonstrate that the treatment processes are sufficient as required. It can be undertaken during pilot stage studies, during initial implementation of a new or alternative water treatment system and is a useful tool in the optimization of existing treatment processes.

The scientific literature, trade associations, regulation and legislation departments, historical data, professional bodies or supplier knowledge are component that can be used for validation the WSP system. Also, by notifying the approving the testing requirements, including the use of specific pathogens or indicator microorganisms. Microbial parameters, such as heterotrophic plate counts and coliform enumeration, which may be inappropriate for operational monitoring, can be used for validation purposes and the design of treatment systems as this does not form part of the routine day-to-day monitoring and management and thus the lag time in receiving the results is not a problem.

12.2 Verification

Verification is the use of methods, procedures or tests in addition to those used in monitoring to determine if the water safety plan agrees with the stated objectives of the water quality targets and/or whether the water safety plan needs adjustment and revalidation.

Verification should involve comprehensive review of monitoring control measures, microbiological and chemical testing, or review of the water safety plan overall to ensure that it is still accurate. For instance, if there have been changes to processes or equipment. To verify system performance, periodic checks are necessary.

12.2.1 Microbial Water Quality

To ensure the microbial level is within the limit, verification is likely to include some microbiological testing. In most cases it will involve the analysis of faecal indicator. Verification for microbial quality of drinking-water should involve the testing from the supplier, surveillance agencies or a combination of both.
Methods of verification contain testing of source water, treatment end-point product and water in distribution systems or stored household water. Verification of microbial level of drinking-water includes testing for Escherichia coli as an indicator of faecal pollution or one of them depending on the available measurement instrument. E. coli provides evidence of recent faecal pollution and should not be detected. In practice, the detection of thermo-tolerant coliform bacteria can be an acceptable alternative in many circumstances. While E. coli is a valuable indicator it has limitations. Enteric viruses and protozoa are more resistant to disinfection and consequently the absence of E. coli will not necessarily indicate freedom from these organisms. Under certain circumstances it may be desirable to include analysis for more resistant microorganisms such as bacteriophages and/or bacterial spores. Such circumstances could include the use of source water known to be contaminated with enteric viruses and parasites or high levels of viral and parasitic diseases in the community.

The value of the water characteristics can vary rapidly, and all water systems are subjected to random failure depending on up normal factors or seasonal factors. For instance, rainfall can greatly increase the levels of microbial contamination in source waters and waterborne outbreaks often occur during and shortly after storms. Results of analytical testing must be interpreted taking this into account.

12.2.2 Chemical Water Quality

At the side, the chemical water characteristics are applied to have change above or below the limits due to multiple factors, therefore, assessment of the adequacy of the chemical quality of drinking-water relies on comparison of the results of water quality analysis with guideline values. For additives like chemicals deriving primarily from materials and chemicals used in the production and distribution of drinking-water, emphasis is placed on the direct control of the quality of these products. In controlling drinking-water additives, testing procedures typically assess the contribution of the additive to drinking-water and take account of variations over time in deriving a value which can be compared with the guideline values.

Emerging disposing of some chemicals such as personal care products that occur in drinking-water are of concern because of effects arising from single exposures or sequences of exposures over a short period. Also, the common chemical disposure rely on the concentration level of the chemical of interest varies widely, even a series of analytical results may fail to fully identify and describe the public health risk. In controlling the chemical hazards, attention must be given to both knowledge of causal factors and trends in detected concentrations, since these will indicate whether a significant problem may arise in the future. Other hazards may arise intermittently, often associated with seasonal activity or seasonal conditions.

Chapter 13
SYSTEM ASSESSMENT, UPGRADING SYSTEMS AND NEW SUPPLIES

The assessment of the water system performance against health-based targets, using either quantitative risk assessment or epidemiological approaches. The results of water investigation can be used to target investment for the upgrading of supplies. Additionally, setting up a water safety plan for a new supply is also described in this chapter.

13.1 Assessing an Existing System against Health-Based Targets

The procedure of assessing a system against established health-based targets is an essential component of the framework for safe drinking-water. The assessment provides an approximation of the safety of the supply in relation to potential impact on public health under the existing design and operational conditions. Assessments are generally assumed through a quantitative risk assessment using data from a range of pathogens, indicator organisms and chemicals. Otherwise, an epidemiological study may be used to evaluate of disease contribution can be ascribed to the water supply, although this approach may be costly, may not capture the risks associated with infrequent events that may lead to outbreaks and is rarely applied in practice.

The following subsections briefly summaries the process of the revision and assessment of the WSP:

13.1.1 Quantitative risk assessments

Quantitative risk assessment methodologies would typically quantify the possible risks arising from:

- Hazards at water source;
- The impact of the system in reducing the threat posed by source water through source protection and treatment;
- The residual risk from the production stage; and
- Risks from recontamination during distribution.

The degree of difficulty of the risk assessment will depend upon available resources. At a very simple level, this may be possible by using a literature-based estimate of the likely removal of pathogens through treatment trains or source protection measures.

The evaluation of pathogens level within the water quality assessment will provide more reliable risk estimates than is possible using indicator or index organisms alone. The evaluation should be simply conducted through using a set of reference pathogens rather than trying to assess the risk posed by possible pathogens present. This method uses a selected range of pathogens whose infectivity and persistence in water is such that control of these pathogens would provide sureness that all pathogens of a similar nature had also been controlled. Suggested reference pathogens include Cryptosporidium parvum, E. coli O157 and rotavirus can be found in (WHO 2004) guidance.
The entered water quality from the source can be varied widely between different locations, but also at one location the water quality may vary over time. If site-specific data are available, the best process to identify the differences is by summarized that using the arithmetic mean concentration.

The average level of pathogens concentration in drinking-water should be determined by combining the concentration in raw water with the degree of reduction afforded by the treatment processes. Again, the reduction due to various treatment processes can be determined empirically or by taking typical levels from the literature. The result of the average pathogens concentration level calculation can be examined against the health-based target, although it may be necessary to convert the result to Disability Adjusted Life Years (DALYs) to account for different pathogen illness severities and to compare against a reference level of 10-6 DALYs per person per year (WHO 2004).

13.1.2 Epidemiological approach

An epidemiological approach is by reviewing the performance against health-based targets will only be used where the health-based targets are stated primarily in terms of control or a reduction in disease as a result of upgrading or improvement in water safety. As a result, it is likely that this approach will primarily be related to diarrheal disease, while it is possible that such approaches may be used for other microbial or chemical contamination. For example, it would be possible to apply this type of approach in communities affected by high arsenic concentration where a switch to arsenic-free water had been implemented, as this can prevent development of further cases or lead to reversal of symptoms.
Even an epidemiological study approach is adopted, it is important to consider how this would be most correctly undertaken. It is not sufficient to rely on passive health surveillance, as the complexity of interpreting the results would be difficult, particularly if assessing the risks related to diarrheal disease.

13.2 Using the Risk Assessment Data for Investment

The risk assessment is very important to determine whether it is necessary to upgrade a system to meet the health-based targets. When failing in the supply system occur as a result of the risk assessment, then investment should be considered, for example, by optimizing existing treatment and/or introducing additional treatment processes. However, the main benefit of using quantitative risk assessment approaches is that a detailed breakdown of where risks occur can be made. As a result of better-informed decisions can be made regarding where investment would deliver the greatest gains.

The risk assessment process would deliver details on the performance of individual processes in the catchment and in removing pathogens or chemicals. Also, the assessment process will provide signs of what increases in risk result within the distribution network and where within the network these occur. Therefore, the targeted investment that will address the causes of increases in risk and therefore deliver cost-effective risk reductions.

By using the DMS system that proposed then we will have suitable risk assessment which will automatically result in the need for new capital investment, and it will also, highlight opportunities to meet targets through improving operational procedures. Resolving these and improving performance may deliver the risk reduction required to meet the health-based targets. Where the risk assessment indicates a need for capital investment, other factors should also be considered, including the actual level of risk posed by the safety of the water supply. For instance, if some areas only have a communal level of service (i.e. public tap) or no access to the water supply then investment in increasing level of service may often bring greater health gains than improving water safety unless the risk estimate from degraded water safety is very high. Similarly, if there is a lack of sanitation, investments in this will generally deliver greater health gains than reducing risks from water supply, unless these are at a very high level.

The Investment decisions that would be assigned by the main stakeholders of the WSP need to be considered in the light of comparative risk assessment in order that balanced decisions are made. Where investment seems necessary, this will not be likely to happen directly and therefore the supplier will also need to develop provisional plans to manage the risk until the capital investment has been achieved.

13.3 Preparing Water Safety Plan for New Supplies

The main elements of the water safety plans should be defined for existing water supplies. However, there are numbers of new water supply or rehabilitation projects that are established for which water safety plans will need to be defined. Water safety plans for new systems will provide comprehensive approach, to a large extent, on the knowledge gained from developing and implementing water safety plans in existing supplies. Some exceptions of that will occur that required to be taken into consideration such as adopting new treatment technologies or advanced technologies. In this, validation of new processes and technologies is essential and must be provided as supporting evidence to the water safety plan when this is under review.

Records collected from the source water quality will provide the basis from which to select the combination of treatment processes and/or other interferences to deliver water that meets the health-based targets. Therefore, the starting point is the reference level of risk that has been determined as acceptable. This is the health-based target expressed in DALYs, e.g. the WHO reference level of risk for infection is 10-6 DALYs /person/year, which is efficiently the same level of risk as the 10-5 excess cancer risk used as the basis for deriving guideline values for carcinogens. As with the risk assessment used to evaluate existing systems this risk level can be used to define a acceptable concentration of pathogens or substances in the final drinking-water produced.

Conclusion

Water safety plan is the most effective tool for ensuring the quality of water supplies. Preparation of a water safety plan may involve several people from the water supply agency and local community to collect information, identify potential hazards that may affect the quality or reliability of supplies, and taking action to minimize the possibility of contamination or interruption of supplies. Water safety plan can be used for water supply schemes of any capacity, from small community schemes to large utility-managed schemes. Appropriate numbers of water supply staff and community members can contribute to the preparation and implementation of the water safety plans, depending on the size of the scheme and management arrangements. Preparation of a water safety plan is part of an ongoing process. The Water Safety Plan will need to be reviewed and revised so that it remains up to date and takes account of experiences of using the water safety plan and changes to the water supply catchment and system. Water safety plans have been prepared in several countries and for water supply schemes of different sizes. Existing water safety plans may be useful as examples, but each water supply scheme needs to be considered separately, to take account of local conditions.

For Iraq Caseload, UNICEF-WASH Programme in coordination and collaboration with the technical staff have introduced, developed and operationalized the Digital Monitoring System (DMS) which could be defined as a tool that using the online system to record the data collected from delegated local staff including the quantity and the quality of water from the source (Tigris, Euphrates rivers mainly and any other bodies of water) and the data collected from the treated water from community water projects. Despite that fact, UNICEF has piloted two Iraqi governorates (Baghdad and Kirkuk) to conduct WSP, UNICEF built the first seed and took into consideration building on the fundamental DMS to maximize and cover other governorates. The new system is designed to cover all management levels of authorities including water service providers, including water quality laboratories and water projects (at technical and managerial level) and the surveillances. The main benefits of applying the new online system in Iraq is to enable the surveillance to have full understanding of water quality and will support the service providers in water sector establish better short- and long-term water resource management planning on water quality and quantity. UNICEF-WASH programme has provided testing instrument for the labs that the water samples will be tested in order to have same harmonized standards and procedure of measurement in order to avoid the variance of the results to have full understanding and fairness to the issue when occur.

Water safety plan applied in Iraq includes the main component that are necessary to assure safe drinking water will be provided to consumer. This report includes the following:

Assemble team: The candidates were identified critically and the responsibility of each were assigned.
Describe water supply: The water supply system was investigated.
Conduct hazard analysis: the identification of potential hazards, hazard event was defined.
Identify control measures, monitoring and corrective actions: This was the stage at which procedures were written. Monitoring and control measures; corrective actions; reporting process; verification information.
Incident response: The Incident Management Procedure was identified for each predicted incident to the system
Supporting programmes: DMS system was applied to the WSP and operational.
Validation, verification and audit: Validation, verification and audit process were identified, and the responsibilities of these processes were assigned.

Finally, the proposed online system (DMS) for the WSP is applicable to all capacities of water supply systems and can be effectively applied in all socioeconomic settings. The water safety planning approach is increasingly being adopted by the Government of Iraq at all levels as best practice for the provision of safe drinking-water.