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PLAN TO COUNTER THE THREATS TO MUNICIPAL WATER SUPPLY AND WATER RESERVOIRS

July, 2010

NATIONAL DISASTER MANAGEMENT AUTHORITY
GOVERNMENT OF INDIA

National Disaster Management Guidelines

Plan to Counter the Threats to Municipal Water Supply and Water Reservoirs

Sub.: **Plan To Counter The Threats To Municipal Water Supply and Water Reservoirs.**

NDMA convened a meeting all of concerned departments and experts dealing with the subject of Safe Drinking Water supply under the Chairmanship of Lt Gen (Dr) JR Bhardwaj, PVSM, AVSM, VSM, PHS, Member, NDMA on 17thMay, 2010. List of participants is attached as **Appendix-A.**

2. The following issues were discussed for preparing a plan to counter the threats to Municipal Water Supply and Water Reservoirs : -

- (i) Water Security
- (ii) Water Quality's Standards
- (iii) Legislative Framework
- (iv) Water Supply System (Current Status)
- (v) Threat Perception
- (vi) Preparedness Plan
  - (a) Prevention
  - (b) Protection
  - (c) Preparedness
  - (d) Detection
  - (e) Threat Characterization
  - (f) Risk Communication
  - (g) Emergency Response
  - (h) Emergency Supply
  - (i) Recovery
- (vii) Guidelines for Standard Operation Plan (SOP)

3. A Core Group of the experts as per **Appendix B** was constituted to formulate and firm up the plan.

4. The document was prepared by the Core Group under the Chairmanship of Lt Gen (Dr) JR Bhardwaj, Member, NDMA and was circulated to all the experts for their final comments if any. The comments from all the representatives were received by 05.06.2010. The comments so received from varuous representatives were incorporated in the document entitled " Plan to counter the threats to Municipal Water Supply and Water Reservoirs''

(Lt Gen (Dr) JR Bhardwaj)

Member, NDMA

CONTENTS

ABBREVIATIONS

ATP	Adenosine Tri Phosphate
ATR	Attenuated Total Reflection
BARC	Bhabha Atomic Research Centre
BIS	Bureau of Indian Standards
CBRN	Chemical Biological Radiological and Nuclear
CPHEEO	Central Public Health and Environmental Engineering Organization
CW	Chemical Warfare
Cs	Caesium
DDMA	District Disaster Management Authority
DNA	Dioxy Ribonucleic Acid
DRDO	Defense Research & Development Organisation
ECL	Electro Chemi Luminescence
ELISA	Enzyme Linked Immunosorbent Assay
ERP	Emergency Response Plan
ERT	Emergency Response Team
EWS	Early Warning System
GC	Gas Chromatography
GDWQ	Guidelines for Drinking-Water Quality
HAZCHEM	Hazardous Chemicals
HRP	Horse radish peroxidase
I	Iodine
IMS	Ion Mobility Spectroscopy
ICMR	Indian Council of Medical Research
MDGs	Millennium Development Goals
MeV	Mega Volt
MoUD	Ministry of Urban Development
MoWR	Ministry of Water Resources
MoEF	Ministry of Environment and Forests
MPN	Most Probable Number
NCC	National Cadet Corps
NDMA	National Disaster Management Authority
NRDWQAC	National Rural Drinking Water Quality Advisory Committee
NSS	National Social Service
PCR	Polymerase Chain Reaction
PPPs	Physical Protection Plan
PWSS	Public Water Supply System
RDD	Radio Dispersal Device
RO	Reverse Osmosis
ROWPU	Reverse Osmosis Water Purification Units
SDMA	State Disaster Management Authority
Sr	Strontium

TCU	True Color Units
TIC/TIM	Toxic Industrial Chemicals/Materials
UN	United Nations
US	United States
VA	Vulnerability Assessment
WPDK	Water Poison Detection Kit
WHO	World Health Organisation
WSS	Water Supply and Sanitation

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1. Introduction

Supply of safe water has long been a key public health and environmental issue. Recognition of the importance of water quality for health dates back to ancient times. Sanskrit writings as early as 2000 BC advocated heating and filtering of water.

The WHO Guidelines defines safe drinking-water, 'as water that does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages.

The importance of safe and adequate drinking water for health and development has also been reflected in the agenda of the United Nations (UN). The UN charter on the "right to water" stipulates that: "the human right to water entitles every one to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses." Under the Millennium Development Goals (MDGs), specific targets are included with the aim of accelerating access to **safe** drinking water and basic sanitation. The United Nations General Assembly declared the period from 2005 to 2015 as the International Decade for Action 'Water for life'.

2. Water Security

Water security is defined as adequate supply of water of assured and sufficient quality to meet the human needs for drinking and other essential uses like food production. In broader terms water security means development, protection, management and sustainable use of fresh water resources in a way to provide equitable access to **adequate** and **safe water** at affordable cost to live a healthy and productive life free from the risk of water-related hazards. Thus, security involves access to adequate quantity and **safe** quality.

Acknowledging the importance of water security, the Steering Committee of Planning Commission On Urban Development For Eleventh Five Year Plan (2007-2012) has also observed to ensure safety of public water supply infrastructure, which is within the reach of anti-social elements, who may disrupt water supply by way of polluting / poisoning of supply, mandatory fencing and other security measures should be ensured to all water supply units to safeguard the health of the public.

3. Water Quality Standards

3.1 National: The Bureau of Indian Standards specification IS: 10500-1991 governs the quality of drinking water supplies in India by public agencies. These are based on International standards for drinking water quality issued by the WHO and the manual of standards of quality for drinking water supplies, ICMR, 1971. A summary of Drinking Water Quality Standards established by BIS is indicated in Annexure-I.

3.2 International: The WHO Guidelines for Drinking-Water Quality (GDWQ), is the most widely accepted international guideline governing water quality standards to protect public health. The Guidelines, prescribes development and implementation of risk management strategies to ensure the safety of drinking-water supplies through control of hazardous constituents of water. These strategies may include national or regional standards developed from the scientific basis provided in the Guidelines. The Guidelines describe reasonable minimum requirements of safe practice constituents of water or indicators of water quality.

4. Legislative Framework

In India, a number of constitutional and legal provisions govern the availability, distribution, control and security of water. The Constitution of India recognizes the essential tenet of equal access to safe water.

Article 15(2) of the Constitution explicitly states that no citizen shall 'on grounds only of religion, race, caste, sex, place of birth or any of them' be subject to any disability, liability, restriction or condition with regard to 'the use of wells, tanks, bathing ghats.

Under **Article 252**, the Parliament has enacted the **Water (Prevention and Control of** Pollution**) Act 1974,** to counter and contain ever growing pollution of natural water resources. This act is the central legislation on which the entire edifice of water exploitation, purification, distribution and protection is based. This Act comprehensively provides the legal basis for prevention and control of water pollution, maintenance and restoration of wholesomeness of water sources in the country. To execute the aforesaid purposes the Act also provides for quality control standards for the taste, color and organic matter.

The Environment (Protection) Act, 1996, has laid down the regulatory framework for activities that could pollute or contaminate environment (accidently or intentionally). The act also mandates criminal proceedings against the defaulters or perpetrators.

5. Water Supply System (Current Status)

The responsibility for the urban water supply and sanitation (WSS) sector in India is shared between the central government and State governments. The central government establishes the policy framework for the management of water resources and provides funds for WSS projects via the budgetary routes. The Ministry of Urban Development (MoUD) is the principal department of the central government that coordinates urban WSS sector activities; the Central Public Health and Environmental Engineering Organization (CPHEEO) is its technical arm. The MoUD receives assistance from the Ministry of Health and Family Welfare, Ministry of Water Resources (MoWR), Ministry of Environment and Forests (MoEF), and the Planning Commission.

The Department of Drinking Water Supply under Ministry of Rural Development is mandated to provide safe drinking water to all rural habitations. The Department of Drinking Water Supply has constituted a **'National Rural Drinking Water Quality Advisory Committee (NRDWQAC)'** to plan and supervise the National Rural Drinking Water Quality Monitoring & Surveillance Programme on a variety of issues like evaluation, standardization and transfer of technology for field testing kits, knowledge sharing for improvement of the quality, accreditation of laboratories, identifying gaps in capacity development programs etc.

The standard water supply system of an urban municipality has one or few centralized water collection and filtration facility that feeds processed / treated water into a network of storage and distribution pipelines. From the central filtration plant the filtered water is distributed through underground pipelines to different areas of the city. There again the filtered water is stored at intermediate storage tanks which may be underground or ground lever reservoirs, open or covered.

The existing municipal water treatment facilities in the country use coagulation, sedimentation, filtration and chlorination as the basic process for water treatment. The contaminants that are currently being addressed are the turbidity, color, odour and microbial contaminants. However, the above said processes being currently used by the municipalities **are not capable of purifying the CBRN contaminated water**.

6. Threat Perception

The importance of freshwater and water infrastructure to human and ecosystem health and to the smooth functioning of a commercial and industrial economy makes water and water systems targets for terrorism. The chance of intentional contamination of water by undesirable person is a strong possibility in present times. There is a long history of such attacks. In 1972, a right-wing, neo-Nazi group known as the “Order of the Rising Sun”, acquired 30–40 kg of typhoid bacteria cultures to use against water supplies in Chicago, St. Louis and other US Cities. Those arrested had in their possession detailed plans for dumping the deadly germs into the water supplies. In 1973, a German biologist threatened to contaminate water supplies with anthrax bacilli and Botulinum unless he was paid a ransom of US$ 8.5 million. In 1983, the Israeli government reported that it had uncovered a terrorist plot to poison the water supply of the city of Galilee with “an unidentified powder”. A chemical poisoning attempt was reported in March 1992, when lethal concentrations of potassium cyanide were found in the water tanks at a Turkish Air Force base Istanbul.

6.1 Threat Scenarios

Water infrastructure can be targeted directly or water can be contaminated through the introduction of poison or disease causing agents. The damage is aimed at inflicting human casualties, rendering water unusable, or destroying purification and supply infrastructure. Although, massive casualties from attacking water systems are difficult to produce, yet the risk of societal disruptions, disarray, and panic are high.

Some important water facilities, such as dams, reservoirs, distribution points, and pipelines are accessible to the public at various points. Many large dams are tourist attractions and offer tours to the public, while many reservoirs are open to the public for recreational boating and swimming. Urban water supply pipelines that dot our urban and rural landscape are often exposed for long distances.

Of growing concern is the risk of CBRN contamination of water systems. This contamination could result either due to natural / accidental contamination, or due to sabotage wherein water-soluble CBRN contaminants can be introduced into a publicly water supply system.

6.2 CBRN Threat

Chemical, Biological, Radiological and Nuclear (CBRN) threat, although non-conventional, is still a real threat being faced by the country. On one hand, these CBRN agents could be used by state adversaries to create mass impact among civilian or Army personnel. On the other hand, chances of these CBRN agents being used by non-state actors to create panic and disruption in densely populated metropolitan cities are also a looming possibility. The extensive water supply system and huge water bodies available in all the populated towns, cities and metros, are soft targets. Most of the water bodies are unprotected. The impact will be slow to begin with, but once spread through the distribution system, would be a difficult task to manage and mitigate. In addition to the CBRN contamination the water supply can be disrupted by sabotage with explosives. An illustrative list of potential Biological, Chemical and Radiological contaminants is appended at Annexure II.

6.2.1 Chemical Contamination

Chemical contaminant may include toxic chemicals, poisons and chemical warfare (CW) agents. These agents exist in liquid, gas, or solid form. The chemicals that can be used for contamination are generally classified in the following categories based on their toxicity and usage.

i. CW agents.
ii. Dual use chemicals.
iii. Toxic Industrial Chemicals/Materials (TIC/TIM).
iv. HAZCHEM and their waste by-products.
v. Agricultural chemicals.
vi. Natural gas and petroleum products.
vii. Other poisonous substances.

TIC/TIM are manufactured, stored, transported and used throughout the country and are easily accessible. Some of the important TICs that can be exploited by terrorists include chlorine gas used in water treatment facilities, phosgene gas used in the urethane foam industry, and anhydrous ammonia used in agriculture, refrigeration, and chemical installations. The important physical effects are generally caused by fire, explosion, and leakage of skin toxicants. Chemically, the agents may affect the lungs, eyes, skin, and blood. Many of them may act as carcinogens. A list of TICs categorised as high, medium, and low threat perceptions along with another list of poisonous chemical and their permissible limits are appended at Annexure III and IV respectively.

6.2.2 Biological Contamination

Security of water against the threat of bioterrorism has also become an issue in recent times as a deliberate act of contamination or damage to water infrastructure is a potential public health threat. Biological agents like anthrax, cholera, plague, salmonella or smallpox can be commonly used for bioterrorism.

Introduction of such agents upstream dilutes the inoculums to non infective levels. Normal enteric pathogens like Vibrio cholera, Salmonella typhi, etc., are successfully removed during the water purification process. Weaponized anthrax spores could possibly survive in potable water but the ease with which the agent can be used as an aerosol would dictate the route of infection. Plague and smallpox likewise are effectively transmitted as aerosols rather than through water in which they undergo a steady decay and probably have higher infecting doses.

Biotoxins can be added to water downstream of the distributing. Among the numerous toxins known the botulinum toxins are probably the agents that can be used by terrorists. The estimated oral lethal dose is 70µg which quantitatively is 70 times more than the aerosol dose and 700 times more than the inspected dose. Therefore its use through drinking water remains a remote possibility. An illustrative list enlisting various waterborne pathogens and its significance to water supply is appended at Annexure V.

6.2.3 Radiological & Nuclear Contamination:

Large water reservoirs, rivers, water treatment plants, header tanks and water supply systems may get contaminated with radionuclides through accidental radioactive fallout following a nuclear detonation or a RDD explosion or intentional addition of water soluble radionuclides in the water body by unlawful elements. The aims of such contamination may be to: expose the public who drink the contaminated water; stop the provision of water supplies to the public; and cause widespread panic and public alarm.

It is probably impossible to contaminate a public water supply with a volume greater than 1000 ^{m3} to a level that would result in immediate fatalities or casualties suffering from the effects of radiation exposure via the ingestion pathway, or that would warrant long term medical follow-up since extremely large amounts of radioactive material would be required to achieve sufficiently high concentrations. Carrying of such high amount of radioactive material may be self defeating on two account; (i) it may be nearly impossible to carry without detection and (ii) it may result in high exposure of the person who carries it. However, it would be possible to contaminate water supplies to levels above the action levels recommended for emergencies.

It may be noted that underground sources of water would remain largely free from such contamination only water stored in open reservoirs are more prone to such contamination. It may also be noted that radionuclide contamination, especially so for gamma emitting radionuclides, in no way affect the purity or potability of drinkable water. In reservoirs and rivers fallout particles that are not soluble in water would sink to bottom and may be held in the mud or vegetation. Furthermore, the fallout radionuclides will rapidly decay and with time only long lived radionuclides will remain. With the constant flow of water in river, the concentration of such nuclides will reduce to large extent and may not pose much hazard to the people using this water. However, reservoir water will remain contaminated for a longer duration.

The most probable nuclides that can be used for terrorism are H-3, Sr-90, I-131 and Cs-137 because of their water solubility and easy availability. As regards to H-3, it is not available in the public domain. Moreover, it poses least risk due to its low beta energy as well as faster excretion from body by resorting to frequent water intake. Thus the main nuclides of concern that can be used for contaminating large water bodies are mainly I-131, Sr-90 and Cs-137.

6.3 Impact:

The number of casualties that would result from CBRN contamination depends on the type of water treatment system, the type and quantity of contaminant, dosage of poison ingested , individual resistance, timing of an attack and early detection and response by local authorities. Most biological pathogens cannot survive in water and most chemicals require very large volumes to contaminate a water system to any significant degree. Many pathogens and chemicals are vulnerable to the routine water treatment that includes chlorination, filtration, ultraviolet radiation, ozonation and many other common treatment approaches. Many contaminants are also broken down over time by sunlight and other natural processes.

The effects of ingested radioactive Sr-90 and Cs-137 will become apparent only at a later stage. Strontium mimics calcium in the body and can radiate radiosensitive bone marrow while behavior of Caesium is similar to Potassium in the body and thus accumulates in cytoplasm and can irradiate DNA. I-131 poses a special risk owing to its accumulation by the thyroid after ingestion.

7. Preparedness Plan

Management of CBRN threat to water resources necessitates a comprehensive action plan that entails specific set of actions for **Prevention, Protection, Preparedness, Crisis Management** and **Recovery**. The core strategy for management of CBRN contamination should primarily focus on mitigation measures including physical protection of water facilities, proper sensitization and training of personnel, procurement of emergency logistics and institutionalization of periodic security check measures.

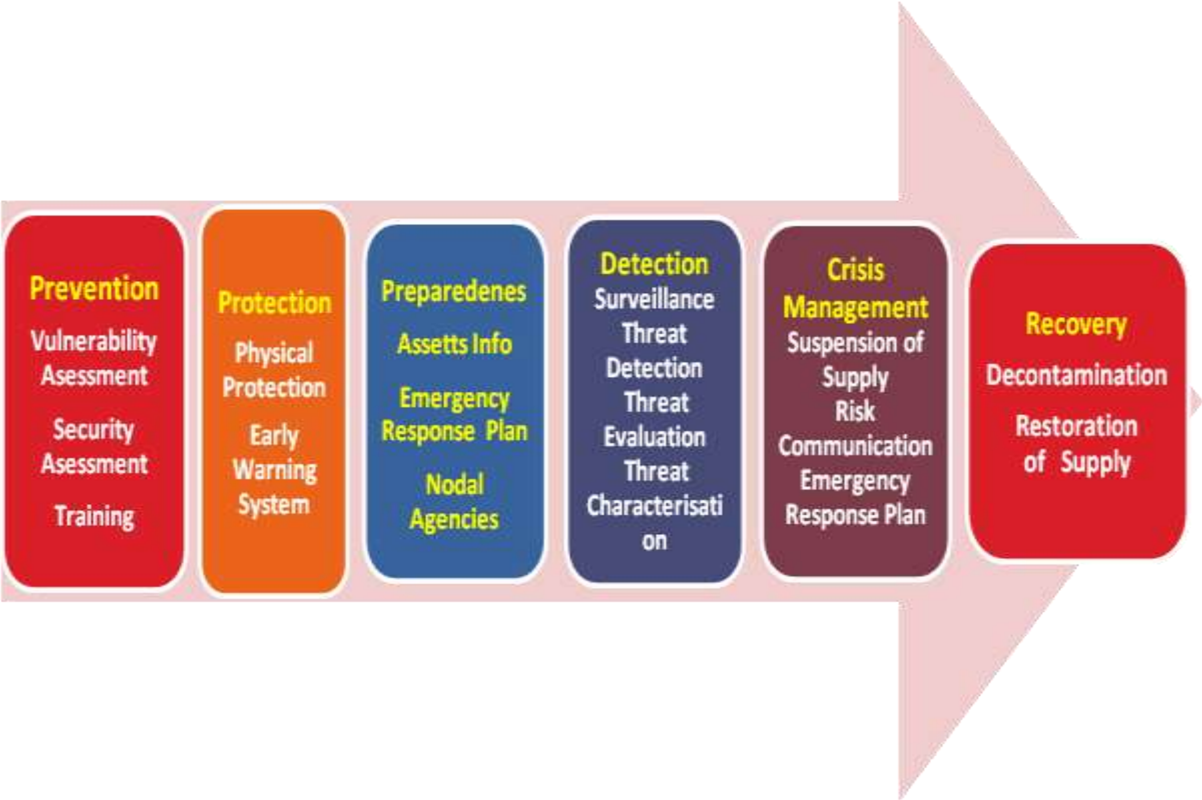

Figure 1: Flow Chart of Operation

7.1 PREVENTION

Entails vulnerability assessment of water facilities, evaluation of current operations, and identification of security gaps, sensitization and training of manpower.

7.1.1 Vulnerability Assessments (VA)

Vulnerability assessments help to evaluate susceptibility to potential threats and identify corrective actions that can reduce or mitigate the risk of serious consequences. A properly conducted vulnerability assessment will identify natural and man-made threats; the potential targets of threats; the degree of risk from threats, and the level of protection provided by existing physical protection plans. Threats may be from vandalism, insider sabotage, or terrorist attack. Threats to public water supply system may also be caused by human error, acts of nature and loss of services. Vulnerability assessments for water systems take into account the vulnerability of the source water, transmission, treatment, and distribution systems. Vulnerability assessment also considers the impacts on the surrounding community related to attacks on the water system. An effective vulnerability assessment serves as a guide to a water utility by providing a prioritized plan for security upgrades, modifications of operational procedures, and policy changes to mitigate the risks and vulnerability to a utility's assets. The vulnerability assessment provides a framework for developing risk reduction options and associated costs.

To ensure water security, the water supply systems should periodically review their vulnerability assessments in close consultation with police and security agencies. The basic elements of vulnerability assessments common to all water supply system are:

- characterization of the water system, including its mission and objectives,
- identification and prioritization of adverse consequences ,
- determination of critical assets / targets that might be subject to emergency situations,
- security profile of the area ,
- assessment of the likelihood and probability of such emergency situations,
- evaluation of existing countermeasures;
- and analysis of current risk and development of a prioritized plan for risk reduction.

A comprehensive set of questioners on Vulnerability Assessment developed by Association of State Drinking Water Administrators (USA) is appended at Annexure-VI. The same may be appropriately modified for use in Indian setting.

7.1.2 Intelligence / Security Assessment

Terrorist attack on water supply infrastructure involving use of CBRN agents is an emerging threat of which our existing water infrastructure facilities are neither familiar nor equipped with. This lack of threat understanding necessitates a continued bilateral interaction with security and intelligence agencies to understand the threat involved and likely implications. The Intelligence and security agencies should periodically evaluate threat perceptions and apprise the same to water infrastructures management on a real time basis. Besides, security agencies may also conduct physical security audit of water facilities in view of its periodic security assessments.

Networking with intelligence and security agencies especially in and around water treatment facilities, storages, and vulnerable stretches of distribution routes for close information sharing, and for updating the law enforcement agencies about the various threats and changed emerging trends.

7.1.3 Training

Capacities required for the management of CBRN contamination of water facilities are grossly inadequate at various levels. Capacity development includes the building of trained and skilled manpower among all functionaries, community resilience using various modes of awareness, and various means of knowledge management.

a. Training modules for security preparedness and crisis management are required to be developed and training imparted to all functionaries of all stakeholders including administrative services.

b. The basic knowledge of CBRN terrorism needs to be imparted at all levels. It is necessary to educate all stakeholders about the likely effects of important CBRN agents that can be used by terrorists.

c. Training of all first responders is an important requirement for the management of CBRN attack.

d. Resident welfare associations and NGOs need to be integrated into the training network to develop volunteerism.

7.2 PROTECTION

7.2.1 Physical Protection Plan (PPPs)

Physical protection plan (PPPs) are intended to mitigate or lessen the impact of threats to public water supply system. Naturally occurring threats and certain man-made threats have been recognized for many years and physical protection plan may be in place in anticipation of these threats. Existing physical protection plan may need upgrading to be protective against Terrorist Threats. Findings of a properly conducted vulnerability assessment will define the necessary improvements needed in the existing physical protection system. Protecting public water supply facilities, equipment and vital records is essential to restoring operations once a major event has occurred. The emergency response plan should identify measures and procedures that are aimed at securing and protecting public water supply system following a major event. The physical protection plan should address the following issues:

- **Deterrence –** through erecting / establishing multilayered perimeter security system and institutionalizing graded access control measures.
- **Detection** - combination of inspection, electronic surveillance, testing and warning systems capable of discovering breach in security.
- **Delay** - the PPPs must effectively delay a terrorist attack from being fully carried out.
- **Defeat** - counterstrategy to neutralize or lessen the impact of accidental or intentional contamination of water supply.

The findings of vulnerability assessment will decide how and in what degree the physical protection plan will need to address the above four areas of concern.

7.2.2 Early Warning System (EWS)

The early warning system is an integrated system designed and deployed for monitoring, detecting, analyzing and interpreting the results to make timely decisions to protect public health from accidental or intentional contamination of water. An effective EWS should include process/ mechanism / technology to

a) detect presence of a contaminant,
b) confirm the presence of the contaminant,
c) determine the nature of the contaminant,
d) and could estimate concentration of the contaminant in the drinking water distribution system.

Figure 2: Design Features of an Early Warning System (EWS) Model

While laboratory technology exists to measure a wide range of substances in the environment, the analytical capabilities of monitors as part of an EWS are limited. Currently available water quality monitors include physical, chemical, radiological, and microbiological analysis as well as bio-monitoring systems that use living organisms as broad spectrum indicators of changes in water quality.

Continuous or real time monitoring is the key to an effective early warning water quality system. However, more important is the appropriate placement of these systems. The first step a plant or supply system must take is to conduct a vulnerability assessment to understand the primary points of risk throughout the water distribution network. Once the vulnerable points are identified, the Early warning systems are installed in each of these points.

7.3 PREPAREDNESS

7.3.1 Assets Information

During a major event, basic technical information about the Public Water Supply System (PWSS) assets needs to be readily available. Asset information needs to be clearly documented and readily accessible so staff can find and distribute it quickly to those who may be involved in responding to the major event.

Basic asset information that may be presented in an ERP includes:

- Public water supply system details like name , location, distribution area etc
- Administrative Contact Person and alternate Administrative Contact Person,
- Population Served and Area of supply,
- Distribution Map,
- Pressure Boundary Map,
- Overall Process Flow Diagrams,
- Site Plans and Facility Engineering Drawings,
- Pumping and Storage Facilities,
- Reservoirs and Retention Facilities,
- Water Treatment Facilities,
- Booster Pump Stations,
- Pressure-Regulating Valve (PRV) Sites,
- Distribution System, Process and Instrumentation Diagrams,
- Equipment and Operations Specifications,
- Emergency Power and Light Generation,
- Maintenance Supplies,
- Operating Procedures and System Descriptions,
- Back-up systems and interconnects with other systems,
- Supervisory Control and Command System,
- Process Control,
- Routine / Emergency Communications System Operation,
- Site Staffing Rosters and Employees' Duties and Responsibilities;
- and Chemical Handling and/or Storage Facilities .

7.3.2 Emergency Response Plan (ERP):

Successful response to an emergency event is largely dependant on pre-emergency planning by the management staff of the public water supply system. The management staff may vary in number from one or two individuals with multiple responsibilities, to large organizations with many individuals contributing to the mission of the organization. Regardless of the size, there are commonalities when planning for and managing an emergency event.

All public water supply system should formulate an Emergency Response Plan (ERP) and constitute an Emergency Response Team (ERT) for coordination and execution of the Emergency Response Plan (ERP). The ERP must also designate an ERT leader and an alternate leader with clearly defined roles and responsibilities.

The ERT leader will be the main point of contact and decision-maker during a major event. This person will have responsibility for evaluating incoming information, managing resources and staff, and deciding on appropriate response actions. The ER Lead will also have the responsibility of coordinating efforts with emergency response partners. The design of the ERP and resulting Physical Protection System is dependent on the community at large from citizens to utility administrators. It is important to establish a design team that crosscuts the community to some degree. Obvious design team members include PWSS staff, first responders and local law enforcement agencies, but the partnerships needed for an effective system are much broader. A design team for a small PWSS will consist of all those who can contribute to the successful design of an ERP and PPS. Design teams for extremely small systems may consist of a few individuals with broad responsibilities, whereas, teams for larger systems may consist of a number of subcommittees dealing with specific issues. An all-inclusive approach to developing partnerships builds confidence that roles and responsibilities will be understood and carried out during an emergency event.

7.3.3 Identification of Nodal Agencies & Departments

Formulation of an effective Emergency Response Plan (ERP) should be followed by identification and enlisting of first responders from departments, agencies and the community at large. An all-inclusive approach to developing partnerships builds confidence that roles and responsibilities will be understood and carried out during an emergency event.

Following agencies / departments should be included in the ERP:

- District Administration
- Municipal Corporation / Municipality / Panchayat
- DDMA/ SDMA/ NDMA
- Water Supply Board / Jal Nigam
- PWD / PHE
- District Health Administration
- District Police
- Fire Services
- Intelligence Agencies
- Town Planning Department,
- District Supply department,
- Department of Transportation,
- Social and Rehabilitation Services,

Community representatives

- School Administration,
- Civil Defense / NCC / NSS
- industrial / trade associations
- doctors, dentists and veterinarians,
- amateur radio clubs,
- Red Cross(RC),
- Print and broadcast media,
- Neighboring communities / Resident Welfare Associations
- Local NGOs

7.4 DETECTION

7.4.1 Surveillance is an investigative activity undertaken to identify and evaluate factors associated with drinking-water which could pose a health risk. Surveillance contributes to the protection of public health by promoting improvement of the quality, quantity, coverage, cost, and continuity of water supplies. Its principal objective is to identify public health risks so that action may be taken promptly to prevent public health problems.

Surveillance requires a systematic programme of surveys that combine analysis, sanitary inspection, and institutional and community aspects. In most countries the agency responsible for the surveillance of drinking-water supply supplies (urban and rural) is the ministry of health. In some countries, the ministry of environment or the ministry of local government may have that responsibility. The surveillance agency should preferably be an established national institution designated by appropriate legislation and should be able to operate at central, provincial and local levels.

Water-quality surveillance requires an appropriate institutional framework and adequate resources (financial, infrastructure & human) to function effectively. Surveillance activities need to be adapted to local conditions and to the availability of local financial resources, personnel, infrastructure and political commitment.

The objective of water quality surveillance is not simply to collect and collate information, but also to contribute to the protection of public health by promoting the improvement of water supply with respect to quality, coverage, cost and continuity.

7.4.2 Threat Detection

The first critical step towards an effective response is proper recognition of a threat warning (i.e., an unusual situation that may have presented the opportunity for contamination of the drinking water). It is important to evaluate the degree of threat being posed by the contamination. Based on the physical evidences and definitive information from intelligence agencies, the water supply facility would evaluate whether or not the activity is suspicious. The common types of threat warnings include:

a) **Security breaches**: is an unauthorized intrusion into a secured facility that may be discovered through direct observation, an alarm trigger, or signs of intrusion (e.g., cut locks, open doors, cut fences). However, every security breach may not constitute a threat as in most cases are related to day-to-day operation and maintenance within the water system.

b) **Witness account**: A threat warning may come from an individual who directly witnesses suspicious activity, such as trespassing, breaking and entering, or some other form of tampering. The witness could be a utility employee, law enforcement officer, citizen, etc.

c) **Direct notification by perpetrator**: A threat may be made directly, verbally or in writing, to the water facility, the news media, law enforcement, or a government agency. Verbal threats made over the phone are the most common type of direct threats from perpetrators; however, there have also been written threats to contaminate the drinking water supply.

d) **Unusual water quality or consumer complaints**: Unusual water quality or an unexplained or unusually high incidence of consumer complaints related to health events may serve as a warning of potential contamination. In order to evaluate this type of warning, it will be necessary to carefully track routinely monitored water quality data and/or consumer complaints such that significant deviations from an established baseline might be observed.

e) **Notification by public health agency**: Notification from a public health agency regarding increased incidence of disease or death is another possible threat warning. A threat triggered by a public health notification is unique in that at least a segment of the population has presumably been exposed to a harmful substance. In this case, public health officials may launch an epidemiological investigation in an attempt to identify the source of the outbreak, during which the utility may be expected to play a support role.

7.4.3 Threat Evaluation:

Once a threat warning is received, the threat evaluation process begins. The emergency response coordinator should be notified immediately. It may be most appropriate to notify the police and security agencies first. The threat evaluation process is considered in three successive stages: 'possible', 'credible', and 'confirmed'. As the situation escalates through these three stages, the actions that will be considered also change. The following describes the stages and actions that might be considered when evaluating a threat warning and activating the ERP.

Stage 1: "Is the threat 'possible'?" Evaluate the available information to determine whether or not the threat is possible (i.e., could something have actually happened?). If the threat is possible, immediate operational response actions might be implemented. Knowing the findings of the vulnerability assessment could help determine if a certain threat is possible.

Stage 2: "Is the threat credible?" There must be information to corroborate the threat in order for the threat to be considered credible. For example, the information source may be highly credible, hospitals may be reporting a potential incident, or monitoring results may be unusual. Having credible information may indicate activating additional portions of the ERP, such as initiating internal and external notifications, conducting water sampling and analysis, or issuing public health advisories. At this stage, preparing to respond is essential if the threat actually leads to a major event.

Stage 3: "Has the incident been confirmed?" Confirmation implies that definitive evidence and information has been collected to establish that an incident has occurred. Confirmation of an incident may be obvious, such as structural damage to a public water supply system. A standard Threat Evaluation Matrix and Threat Evaluation Worksheet have been appended at Annexure VII & VIII respectively for preparing similar evaluation plan for the water facilities in Indian setting.

Confirmation of an incident should fully activate the ERP including applicable action plans. The ER Leader should work through the threat decision process and implement the ERP as needed. Judgment must be exercised when determining how to appropriately manage a specific threat or incident.

Suspension of regular supply: Upon receiving the on site confirmation of contamination, the water supply from the water facility to its entire distribution network should be stopped immediately.

7.5 THREAT CHARACTERIZATION / LABORATORY TESTINGS

7.5.1 Pre-Identification of Laboratories Laboratory network is an important support for quick detection and characterisation of contaminants for diagnosis and management. At present, the laboratories at various levels lack capabilities and capacities for detection of CBRN agents. All water facilities / authorities must identify and collaborate with primary and reference laboratories for timely detection and characterisation of CBRN agents.

7.5.2 Sampling: Samples of each potential drinking water source should be obtained for chemical, biological and radiological analysis to evaluate its treatability characteristics. For collection of sample clean dry container will be collected by trained first responders. The collection of sample for biological agents shall be collected in sterile container.

It is essential to collect paired sample from each suspected source of which one will be retained by the authority and stored at 4 degree centigrade for future reference. The second sample will be divided into two halves, one for the spot testing and another will be sent to reference laboratory for confirmation and characterization. A detailed guideline on sample collection is given at Annexure IX.

7.5.3 On site Screening Tests: Whenever CBRN contamination is suspected, following two types of tests are required to be done at the earliest.

a. Preliminary Screening Tests: Contamination by CBRN agents is likely to change physical and chemical characteristics of water. Therefore following tests shall be used as preliminary screening tests :

Turbidity: Drinking water with obvious turbidity above 5 NTU becomes unacceptable to the consumer. Turbidity indicates incomplete treatment of water or contamination with organic or biological agents.

Color: The acceptable limit for color in drinking water is 15 true color units (TCU). Coloration of water indicates presence of organic matter, metals, or industrial wastes.

Taste and odour: Even though no prescribed limit or values have been laid down, any water with significant degree of taste and odour is unacceptable to the user. Unpleasant taste and odour indicates presence of organic matter, toxic chemicals and occasionally due to excessive residual chlorine in treated water.

pH : The guideline value for pH of water is 6.5 to 8.5.Water with pH levels below this range indicates presence of certain chemical contaminants such as lead.

b. Definitive Screening Tests:

Water Poison Detection Kit: Water Poison Detection Kit (WPDK) developed by DRDO can be used effectively to check the water for the presence of water poisons such as cyanide, arsenic, lead, copper, mercury, cadmium, chromium, nerve agents (Soman, Sarin, Tabun, Vx, etc.) and blister agents (sulphur mustard) based on spot test. This kit performs the detection of these highly toxic chemical agents up to their permissible limits as prescribed by WHO.

Severn Trent Field Enzyme Test: is used for qualitative detection of nerve agents in a field setting. The test is based on the inhibition of the enzyme cholinesterase. A membrane disk is saturated with cholinesterase and dipped into a water sample for one minute. If no pesticide/nerve agent is present in the water sample, the cholinesterase on the membrane disk hydrolyzes esters resulting in the formation of a blue color. If sufficient concentrations of pesticide/nerve agent are present, the cholinesterase on the membrane is inhibited, the ester is not hydrolyzed, and there is no change in color (remains white). The detection limits cited by the manufacturer for pesticides are: carbamates (0.1 to 5 mg/L); thiophosphates (0.5 to 5 mg/L); and organophosphates (1 to 5 mg/L).

Presumptive coliform test: This test is based on estimating the most probable number (MPN) of coliform organisms in 100 ml of water. This method gives rapid results enabling one to take quick decision in the field about the contamination. The McConkey broth medium is inoculated with 10 ml of the suspected water sample and incubated for 24 hr after. Thereafter sample is checked for the presence of acid or gas that which none of the bottles should show acid or gas.

The Eclox TM kit is a broad screening kit with multiple tests in the kit. The main test is the chemiluminescence test. It is based on the production of light by the reaction of

luminol and an oxidant in the presence of a catalyst enzyme. The addition of an enhancer allows a steady output of light to be measured by the Luminometer. Contaminants in a water sample will suppress the reaction and reduce the light output relative to a clean reference sample.

Note: There is no single screening method or kit that tests for all possible radiological, chemical, or biological contaminants. Therefore, screening test should be used only as a threat evaluation tool, not as the final solution. A negative screening result may not necessarily rule out contamination.

7.5.4 Confirmatory Laboratory Testing

a. Biological Contamination

Membrane filtration technique: In some countries membrane filter technique is used as a standard procedure to test for the presence of coliform organisms. A measured value of the water sample is filtered through a membrane made of cellulose ester. Bacteria present in water are retained on the surface of the membrane. The membrane is then directly inoculated face upwards on suitable media at appropriate temperature. Within 20 h the colonies grow and can be counted.

Colony count: The colony on nutrient agar at 37°C and 22°C provide an estimate of the general bacterial content of water. A single count is of little value, but counts from the same source at frequent intervals are of considerable value. A sudden increase in the count serves as the earliest indicator of contamination and hence this test is gainfully used in the public water works. The recommended plate counts are:

Water at the point of consumption	Plate count after 2 days at 37°C	Plate count after 3 days at 22°C
Disinfected	0	10
Not disinfected	20	100

Plate count on yeast extract agar at 22°C for 7 days is even a better indicator due to the absence of chlorine residue when there is uninhibited bacterial growth.

Colilert method: The World Health Organization recommends the measurement of Escherichia coli in drinking water samples as the best indicator of water quality. The WHO guideline for the potable water is less than one E coli per 100 ml of drinking water (WHO1998). Multiple tube fermentation, membrane filtration and Colilert are laboratory methods used to qualify the level of bacteria in drinking water samples. The multiple tube fermentation membrane filtration test measure total coliform as E.coli and are standard methods for water quality assessment. Colilert is simple to use, allows greater throughput, and requires less time to standardize then standard methods. Colilert or other similar methods are acceptable to measure the presence and quantity of coliforms in water samples in the developing country setting.

Flow Cytometry: is a general technique that is used in medical applications and analysis of environmental microbial populations. A monodisperse suspension of cells flows past a laser beam (or in some more complicated instruments, multiple laser beams) and the device measures properties of each cell, such as size, granularity, green fluorescence, red fluorescence, and far red fluorescence intensities. Fluorescent tags can be used for a variety of general or specific cell components, such as DNA, RNA, proteins (antigens), or other target molecules. Some microorganisms can be distinguished on the basis of differential light scatter properties with the addition of fluorescent tags. Dyes that stain only live cells can be added to samples so that the flow cytometer can quantify the level of live versus dead cells. Nucleic acid intercalating dyes can be used to determine DNA/RNA ratios and adenine-thymine/cytosine-guanine content which helps further characterize the cells in a sample and could be used to identify microorganisms in some cases. Fluorescently labeled antibodies can also be used to identify specific organisms in aerosols, water, soil, and food.

Light Scattering Technology: Light scattering technology is a simple scanning procedure that provides information about the presence of particles of a certain size. When a laser beam is sent through flowing water, the laser light is scattered at right angles by the presence of particles in the water. Optical devices such as photodiodes collect the scattered light, which can be analyzed to determine the size and number of particles present in the water sample.

Immunoassays: The principle behind rapid immunoassay technologies is to detect the antigen-antibody reaction. Specific antigens in the water are bound to corresponding antibodies through targeting of specific proteins. The presence of a microbial contaminant is "seen" when specific antigen proteins in the sample bind with the corresponding antibodies. Immunoassays have been used since the early 1980s for many research, clinical, and safety/quality control applications.

Polymerase Chain Reaction (PCR): is an analytical technique that detects/identifies organisms by targeting their nucleic acids (DNA/RNA). PCR is a highly developed technology for molecular biology applications. It has broad applicability for almost any situation where DNA needs to be detected and identified.

Strip Tests - Lateral Flow Assay: The lateral flow assay is a general technique for detecting antigens. It is a simplified version of ELISA. The test strip is an absorbent membrane mounted on a stiff (plastic) backing, often contained in a plastic cassette. A liquid sample is applied to one end of the strip, the sample diffuses along the length of the strip, passing several stripes (narrow regions) impregnated with high concentrations of specific antibodies, which are labeled with colored dyes or fluorescent agents. When the antigen-labeled antibody complex migrates to the test stripes, a color change or fluorescent signal indicates the presence of the target antigen. A control stripe beyond the test stripe serves as a positive control, indicating proper diffusion and appropriate functioning of strip reagents. Home pregnancy tests are lateral flow assays. Traditional lateral flow assays produce color changes that can be detected with the naked eye. Newer fluorescent and phosphorescent reporters require excitation light and/or light detection devices.

Detection of Bacterial ATP: A common indicator for microbial presence used in the food and beverage industry is ATP. Tests for ATP are now being used for rapid detection of microbes in water, such as cooling towers. A small volume of water (typically < 20 milliliters) is required and the test takes between 30 seconds and a few minutes depending on the kit. Either free ATP or microbial ATP can be measured. To measure microbial ATP, cells in the water sample are lysed to release ATP into the solution. To detect only ATP contained within living bacterial cells, the water sample must first be filtered to collect the cells and rinse away non-bacterial ATP, and then the cells are lysed to release ATP.

Electro-chemi-luminescence (ECL): ECL is a detection technology that utilizes light generated by the oxidation and reduction of a ruthenium metal ion as a labeling system. Capture molecules (e.g., antibodies) are absorbed onto a support surface, such as magnetic beads or a microarray plate. The addition of target molecules from the sample and ruthenylated antibodies creates an antibody sandwich which is detected when the ruthenylated antibodies are stimulated to glow with an electrode. Background signal is limited because the electrodes only stimulate nearby ruthenium, quenching is not a problem with the 620 nm emitted light. As with other antibody-based technologies, volume reduction would most likely be required for ECL technologies to be adapted for distribution systems.

An illustrative list of recommended laboratory identification methods for Biological Warfare Agents is appended at Annexure-X.

b. Chemical Contamination Testing

Chemiluminescence detection technique based on the reaction of luminol and an oxidant in the presence of the enzyme horseradish peroxidase (HRP) can be used to indicate the presence of toxins in a sample. The HRP mediated reaction produces light that is measured by a luminometer. Phenols, amines, heavy metals, or compounds that interact with the enzyme reduce light output and indicate contamination.

Gas Chromatography: GC can be used to analyze for a wide variety of organic chemicals such as industrial chemicals and components of fuel oils. Individual organic compounds are separated as the compounds are carried by a carrier gas (e.g., nitrogen, helium, argon, hydrogen) through a packed or coated column containing a stationary phase. The columns are coiled in an oven. At the beginning of the coil, the compound is vaporized into a gas. The compounds separate from each other within the column due to differing affinity among the sample compounds for the gas and liquid phases. As a result, the individual compounds travel through the column at different speeds. The time required to pass completely through the column and reach the detector varies from compound to compound. The components of a complex sample matrix can be separated, compared to known standards, and the concentrations then quantified. For smaller devices, photolithographic machining techniques are used to produce injection and detection systems on silicon microchips GC alone can only provide tentative identification. For more definitive identification, traditional and micro fabricated GC columns can be coupled to detectors such as Thermal Conductivity Detector (TCD), Surface Acoustic Wave Detector (SAWD), Electrolytic Conductivity Detector (ECD), Electron Capture Detector (ECD), Flame Ionization Detector (FID), Photo Ionization Detector (PID), and Mass Spectrometer. Volatile Organic Compounds (VOCs) can be extracted and concentrated from water samples using purge and trap technology. The volatile compounds are initially purged from the water sample using a purge gas such as helium and are absorbed onto an organic resin trap. The compounds are subsequently desorbed from the trap by flash heating and enter the GC column. Purge and trap gas chromatography has been used for years to monitor raw waters for industrial spills. In some cases analyses are conducted on grab samples one or more times each day. In other cases sample collection has been automated and occurs at regular intervals throughout a 24-hour period. The units require skilled operators and regular maintenance.

Biosensors work to identify toxic substances in the water using whole-organism or cellular response approaches. Biosensors measure changes in physiology or behavior of living organisms resulting from stresses induced by toxins. This type of biosensor does not identify the specific toxin, but indicates that there is an unusual condition in the water. The overall rationale is that the organism can respond with sensitivity to all the factors that contribute to stress. Fast acting toxins associated with acute effects are most quickly detected. However, slower acting toxins or toxins with chronic effects would not be rapidly detected if they do not also have acute effects. It is important to note that the biosensors presented are not effective for detecting human pathogens because pathogens are often species- or tissue-specific and require incubation times (typically days or weeks) before disease symptoms are noticeable.

Infrared Spectroscopy: is another precision technology used for identification of

a variety of weapons of mass destruction, toxic industrial chemicals, narcotics, and explosives. This is a portable tool using Fourier Transform Infrared (FT-IR) Attenuated Total Reflection (ATR) spectroscopy for field identification of analytes in the solid or liquid phase.

Ion Mobility Spectroscopy (IMS) is a technique for identifying and measuring water contamination by volatile compounds. An ambient air or vapor sample is drawn over a semi-permeable membrane. Smaller volatile compounds pass through the membrane into the detection cell, where the sample is ionized by weak plasma formed by a nickel-63 radioactive source. The ionized sample molecules drift through the cell under the influence of an electric field. An electronic shutter grid allows periodic introduction of the ions into a drift tube where they separate, based on charge, mass, and shape. Smaller ions move faster than larger ions through the drift tube and arrive at the detector sooner. The amplified current from the detector is measured as a function of time and a spectrum is generated. A microprocessor evaluates the spectrum for the target compound, and determines the concentration based on the peak height. IMS is used in explosives detection equipment at airport security check points. There are several portable IMS sensors for chemical detection but all have been designed for use with air/vapor samples.

c. Radio-Nuclear Contamination Testing

A number of rapid and in-situ measurement techniques during post-accident scenarios of a nuclear power plant have been developed and standardized. These techniques are sensitive enough to detect the activity levels corresponding to lower limit of intervention levels for speedy implementation of protective measures on the early and intermediate phases of nuclear accidents. The techniques include measurement of ^{131}I activity in milk and ground contamination with ^{131}I, ^{137}Cs and also the fraction of ^{131}I component in a mixture of ^{131}I and ^{137}Cs.

Detection of Beta emitters: The in-situ detection of beta emitters in water is difficult as it needs chemical separation of these nuclides and then counting after plancheting. However, costly portable liquid scintillation systems may be used to detect qualitatively as well as quantitatively Sr-90 and H-3 in-situ. The system and measurement protocol for detection of H-3 in water is given in Annexure -1. Similar protocol can be adopted for Sr-90.

The Triathler's portable liquid scintillation counter is a very compact system. This can be used for in-situ estimation of beta emitters in water like Sr-90, H-3, S-35 etc.

Tritium in water monitor: For tritium, since the beta range is in the submicron levels in solids, the sample must be placed inside the scintillator material, or a very thin solid scintillator must be used.

The tritium-in-water monitor developed in RSSD/BARC is based on plastic scintillator sponge type flow cell detector. The detector cell is optically coupled to two photomultiplier tubes and measurement is done in coincidence mode. The sample water is continuously passed through the flow cell and it could measure a minimum activity concentration of 1 nCi/ml (40 Bq/ml). The polypropylene bag, polypropylene candle and glass fibre filter paper filters the sample for particulate substances. Activated charcoal adsorbs the organic compounds, free chlorine and fungus and thereby eliminates the interference due to chemiluminescence.

Detection of Gamma Emitters: Rapid estimation of gamma emitting radionuclides of interest i.e., ^{137}Cs, and ^{131}I and any other like ^{60}Co, ^{133}Ba etc in water samples can be accomplished by the application of in-situ gamma ray spectrometry technique using portable spectrometer employing NaI(Tl) detector. For the detection and analysis of radionuclides with gamma energies less than 2 MeV, NaI(Tl) detector of size 2"x2" is sufficient. Very stable and compact battery operated multichannel analyser system with at least 512 channels is required for PHA (Pulse Height Analysis) of detector output. At present commercially available Identifinder or FieldSpec is having the similar configuration (1.4"dia x 2" NaI(Tl) with 1k MCA). This system can operate as a portable spectrometer and has the capacity to store 100 spectrums. It operates on battery power and also can be operated on mains supported DC adapter. The stored spectra can be transferred to Laptop PC via USB cable using Identifinder transfer package. The offline analysis of the stored spectrum can be carried out using TMCA32 software supplied along with the system. The software also has the features like background subtraction, peak area estimation etc. The stored spectral data can be later used for further quantitative analysis, if required.

7.6 RISK COMMUNICATION

Appropriate and timely communication to first responders as well as public is essential during an emergency. The ERP coordinator should identify clear communication channels for public water supply system personnel, first responders, public and the media. The ERP should maintain internal and external notification lists that contain information on all appropriate entities to be contacted, including names, titles, mailing addresses, e-mail addresses, all applicable land line and cellular phone numbers, radio call frequencies, and pager numbers.

In the event of detection of breach of security at water works premises or contamination, local police and law enforcement agencies should be informed on priority. Thereafter, details of the preliminary findings or hazard assessment explaining probable consequences should be communicated to the authorities both verbally and in writings.

A timely and effective public communications is crucial to minimize the health hazard due to contamination. However, to avoid confusion and panicky a public the authority would designate a Public Information Officer (PIO) in advance to manage to and fro exchange of information with public and media. The PIO should have good communication skills, and if possible familiarity with Emergency Response Plan (ERP). Public communication by unauthorized personnel should be avoided strictly.

7.7 EMERGENCY RESPONSE

7.7.1 Emergency Response (Crisis Management): A timely and effective response will be based upon an emergency response plan which will include roles and responsibilities of various stakeholders, responders, and service providers including the private sector; factors governing the establishment of Incident Command (IC) posts, relief centres, medical units, and specialised hospital care; and various coordination protocols. The medical authorities should also be asked to keep their health contingency plan ready.

7.7.2 Emergency supply: A responsibility of the public water supply systems is to provide quality water in quantity. When an emergency occurs, an alternate water supply may be needed. Alternate water sources could include potable water from a nearby public water supply systems any other river, dam or deep wells. Bottled water from commercial suppliers offers temporary and limited relief. Consideration must be given regarding the amount of water needed for short-term (hours to days) and long-term (weeks to months) outages. The ERP should identify the alternate water supplies available for both types of outages.

7.8 RECOVERY

7.8.1 Decontamination: In case safe water supply cannot be restored quickly, the authority may have to resort to decontamination, for which following methods are recommended :

a) Reverse Osmosis(RO) based procedure: RO based water purification technique has been found to be very useful to decontaminate the water of nearly all types of CBRN contaminations except H-3. Such systems and plants have been developed by DRDO and BARC. DRDO Laboratory at Jodhpur has developed a 'Mobile Water Purification System' for disaster situations having a capacity of purifying 2000 l/hr of NBC contaminated water. The system is mounted on a vehicle ensuring mobility for fast response and has its own power source and all the required sub-components, thus making it self sufficient in all the respects. The RO based Mobile Water Purification System has been evaluated for its performance parameters on salinity, turbidity, Nuclear, Biological & Chemical agents by DRDE Gwalior and DRDO Laboratory Jodhpur. The output water fully meets the existing international standards for the potable water.

b) Purification using suitable clay minerals based nuclide selective adsorbents: Following natural clay based minerals have been found to be isotope selective adsorbents :

Iodine isotopes- Natural clay coated with silver nitrate is a good adsorbent.

Strontium-90 - Kiolinite based clay minerals

Cesium-137 - Smecitite based clay minerals.

Thus addition of suitable clay mineral composition, agitation, followed by filtration in batch process can be used for removal of radioactivity from water. This method can remove >90 % of activity.

c) Decontamination of H-3 contaminated water: Ideally speaking H-3 does not have potential as external hazard due to very low beta energy. Even the internal hazard posed by H-3 due to inhalation or ingestion is very low. Furthermore, it can be easily be excreted from the body by intake of large amount of water. Thus as such decontamination of water contaminated with H-3 is not so critical. However, specialized techniques like 'inverse distillation' followed by 'liquid phase catalytic exchange' process can be used.

7.9 RESTORATION OF NORMAL SUPPLY

Normal supply of safe water should be restored at the earliest minimum Qualtitity of water (as per national guideline) should be restored immediately by arranging water from other sources followed by general restoration of the normal supply.

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8. Crisis Management: Standard Operation Procedure (SOP)

An orderly and effective execution of any emergency response plan necessitates a set of sequential actions to be carried out by pre designated official or authority. To manage an incident of CBRN contamination of water supply, a modal SOP as given under may be referred to:

1. Incident Reporting

- Any breach of security or suspected event of accidental or intentional contamination should be communicated to the officer in charge of the water facility through quickest possible means.
- Subsequently, he will inform the same to local police, law enforcement and intelligence agencies, and request for physical quarantine of the contamination site.
- The incident should also be reported to all pre-identified nodal agencies with request to remain at stand by.

2. Site Characterization

- Water facility in charge along with law enforcement agencies would visit the site and make on site inspection for identification of physical evidences to confirm the incident.
- Police & Law enforcement agencies would collect and preserve physical evidences for further investigation and necessary action.
- Water facility in charge will also make an initial hazard assessment based on available evidences for determining potential need for specialized men, material, techniques or equipment.
- Based on the findings of initial site evaluation, both to and fro water supply should be stopped immediately.

3. Preliminary Screening

- Trained personnel would be deployed for sample collection and spot testing as described in this document.
- Sample should be collected from the nearest point.
- Sample collected should be divided into two, one for spot testing and another for laboratory testing.
- First set should be subjected to spot testing by prescribed methods.
- Once the incident and nature of contamination is established the same should be communicated to district administration in precise and clear language for activating their crisis management plan.
- Following positive screening, second half of the sample should be immediately sent to pre identified reference laboratories.

4. Risk Communication

- District administration in association with disaster management authority will make public pronouncement of contamination event in clear and precise language along with requisite precautions to be taken.
- All care to be taken to avoid undue panic situation.

5. Alternate Supply

- The Water facility manager in association with district administration would make alternate supply arrangements.
- In absence of alternate supply, water should be decontaminated through the technique of reverse osmosis. The mobile water purification van developed by DRDO could be utilized for same.

6. Decontamination

- Supply lines and storage facilities should be decontaminated using appropriate and available technology. Do not try to decontaminate water that has been exposed to chemical agents by using chemicals; rather it should be purified through the systems based on Reverse Osmosis and Carbon Columns. Such a system has been developed by Defence Laboratory, Jodhpur and is named as Water Purification System (WPS) and it is suitable for purification of water including that contaminated by CBRN agents.

7. Restoration of supply

- Following repair and decontamination of facility, a fresh water sample should be retested and certified for public consumption.
- Following certification, water supply should be restored.

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9. Annexures

Annexure -I

Drinking Water Quality Standards (IS: 10500)

Sl. No.	Characteristics	* Desirable Limit	** Permissible Limit
	<u>Physical and Chemical Standards</u> :		
1.	Turbidity (units on NTU scale)	5.0	10
2.	Colour (units on Hazen scale)	5.0	25
3.	Taste and Odour	Unobjectionabl	Unobjectionable
4.	pH	6.5 – 8.5	No relaxation
5.	Total Dissolved Solids	500	2000
6.	Alkalinity, mg/l	200	600
7.	Total Hardness, mg/l, as $CaCO_3$	300	600
8.	Chlorides, as Cl, mg/l	250	1000
9.	Sulphates, as SO_4, mg/l	200	400
10.	Fluorides, as F, mg/l	1.0	1.5
11.	Nitrates, as NO_3, mg/l	45	No relaxation
12.	Calcium as Ca, mg/l	75	200
13.	Magnesium, as Mg, mg/l	30	150
	(If Sulphate is present to the extent of 250 mg/l, Magnesium is increased to 125 mg/l at the rate of one unit for every 2.5 unit of Sulphate.)		
14.	Iron, as Fe, mg/l	0.1	1.0
15.	Manganese, as Mn, mg/l	0.1	0.3
16.	Copper, as Cu, mg/l	0.05	1.5
17.	Zinc, as Zn, mg/l	5.0	15
18.	Phenolic compounds, as phenol, mg/l	0.001	0.002
19.	Anionic detergents, as MBAS, mg/l	0.2	1.0
20.	Mineral oil, mg/l	0.01	0.03
21.	Arsenic, as As, mg/l	0.05	No relaxation
22.	Cadmium, as Cd, mg/l	0.01	No relaxation
23.	Chromium, as hexavalent Cr, mg/l	0.05	No relaxation
24.	Cyanide, as Cn, mg/l	0.05	No relaxation
25.	Lead, as Pd, mg/l	0.05	No relaxation
26.	Selenium, as Se, mg/l	0.01	No relaxation
27.	Mercury, as Hg, mg/l	0.001	No relaxation
28.	Polynuclear aromatic hydrocarbon (PAH)	0.2 μg/l	No relaxation
29.	Gross Alpha emitters, Bq/l	-	0.1
30.	Gross Beta emitters, pci/l	-	1.0

Note:

1. ***The figures indicated under the column "Desirable" are the limits up to which water is generally acceptable to the consumers.**

2. **** The figures in excess of those mentioned under "Desirable" render the water not acceptable, but still may be tolerated in the absence of alternative and better source but up to the limit indicated under column "Permissible Limit" above which the supply shall have to be rejected.**

3. **It is possible that some mine and spring waters may exceed these radio activity limits and in such cases it is necessary to analyse the individual radionuclide in order to assess the acceptability or otherwise for public consumption.**

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Annexure- II

Drinking Water Contaminant Classes and Examples

Category	Examples
MICROBIOLOGICAL CONTAMINANTS	
Bacteria	Bacillus anthracis, Brucella spp., Burkholderia spp., campylobacter spp., Clostridium perfringens, E. coliO157:H7, Francisella tularensis, Salmonella typhi, Shigella spp., Vibrio cholerae O1, Yersinia pestis, Y. enterocolitica
Viruses	Calciviruses, Enteroviruses, Hepatitis A/E, Variola, Venezuelan equine encephalitis virus
Parasites	Cryptosporidium parvum, Entamoeba histolytica, Toxoplasma gondii
CHEMICAL CONTAMINANTS	
Corrosives and caustics	Toilet bowl cleaners (e.g., hydrochloric acid), tree-root dissolver (e.g., sulfuric acid), drain cleaner (e.g., sodium hydroxide)
Cyanide salts or cyanogenics	Sodium cyanide, potassium cyanide, amygdalin, cyanogens chloride, ferricyanide salts
Metals	Mercury, lead, osmium, their salts, organic compounds, and complexes (even those of iron, cobalt, copper are toxic at high doses)
Nonmetal oxyanions, organononmetals	Arsenate, arsenite, selenite salts, organoarsenic, organoselenium compounds
Fluorinated organics	Sodium trifluoroacetate (a rodenticide), fluoroalcohols, fluorinated surfactants
Hydrocarbons and their oxygenated and /or halogenated derivatives	Paint thinners, gasoline, kerosene, ketones (e.g., methyl isobutyl ketone), alcohols (e.g., methanol), ethers (e.g., methyl tert-butyl ether or MTBE), halohydrocarbons (e.g., dichloromethane, tetrachloroethene)
Insecticides	Organophosphates (e.g., Malathion), chlorinated organics (e.g., DDT), carbamates (e.g., Aldicard) some

	alkaloids (e.g., nicotine)
Malodorous, noxious, foul-tasting, and/or lachrymatory chemicals	Thiols (e.g., mercaptoacetic acid, mercaptoethanol), amines (e.g., cadaverine, putrescine), inorganic esters (e.g., trimethylphosphite, dimethylsulfate, acrolein)
Organics, water-miscible	Acetone, methanol, ethylene glycol (antifreeze), phenols, detertgents
Pesticides other than insecticides	Herbicides (e.g., chlorophenoxy or atrazine derivatives), rodenticides (e.g., superwarfarins, Zinc phosphide, α-naphhyl thiourea)
Pharmaceuticals	Cardiac glycosides, some alkaloids (e.g., vincristine), antineoplastic chemotherapies (e.g., aminopterin), anticoagulants (e.g., warfarin). Includes illicit drugs such as LSD, PCP, and heroin
Schedule 1 Chemical Weapons	Organophosphate nerve agents (e.g., sarin, tabun, VX), vesicants, [nitrogen and sulfur mustards (chlorinated alkyl amines and thioethers, respectively)], Lewisite
Biotoxins	Plant, animal, microbial, and fungal derived toxins (e.g. ricin, botulinum toxin, aflotoxins)
RADIOLOGICAL CONTAMINANTS	
Radionuclides	Does not refer to nuclear, thermonuclear, or neutron bombs. Radionuclides may be used in medical devices and industrial irradiators (e.g. Cesium-137, Iridium-192, Cobalt-60, Strontium-90). Class includes both the metals and salts.

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Annexure-III

Classification of Toxic Industrial Chemicals as High, Medium and Low Risk Chemicals

High	Medium	Low
Ammonia	Acetone cyanohydrin	Allyl isothiocyanate
Arsine	Acrolein	Arsenic trichloride
Boron trichloride	Acrylonitrile	Bromine
Boron trifluoride	Allyl alcohol	Bromine chloride
Carbon disulfide	Allylamine	Bromine pentafluoride
Chlorine	Allyl chlorocarbonate	Bromine trifluoride
Diborane	Boron tribromide	Carbonyl fluoride
Ethylene oxide	Carbon monoxide	Chlorine pentafluoride
Fluorine	Carbonyl sulfide	Chlorine trifluoride
Formaldehyde	Chloroacetone	Chloroacetaldehyde
Hydrogen bromide	Chloroacetonitrile	Chloroacetyl chloride
Hydrogen chloride	Chlorosulfonic acid	Crotonaldehyde
Hydrogen cyanide	Diketene	Cyanogen chloride
Hydrogen fluoride	1,2-Dimethylhydrazine	Dimethyl sulfate
Hydrogen sulfide	Ethylene dibromide	Diphenylmethane-4,4'-diisocyanate
Nitric acid, fuming	Hydrogen selenide	Ethyl chloroformate
Phosgene	Methanesulfonyl chloride	Ethyl chlorothioformate
Phosphorus trichloride	Methyl bromide	Ethyl phosphonothioic dichloride
Sulfur dioxide	Methyl chloroformate	Ethyl phosphonic dichloride
Sulfuric acid	Methyl chlorosilane	Ethyleneimine
Tungsten hexafluoride	Methyl hydrazine	Hexachlorocyclopentadiene
	Methyl isocyanate	Hydrogen iodide
	Methyl mercaptan	Iron pentacarbonyl
	Nitrogen dioxide	Isobutyl chloroformate
	Phosphine	Isopropyl chloroformate
	Phosphorus oxychloride	Isopropyl isocyanate
	Phosphorus pentafluoride	n-Butyl chloroformate
	Selenium hexafluoride	n-Butyl isocyanate
	Silicon tetrafluoride	Nitric oxide
	Stibine	n-Propyl chloroformate
	Sulfur trioxide	Parathion
	Sulfuryl chloride	Perchloromethyl mercaptan
	Sulfuryl fluoride	sec-Butyl chloroformate
	Tellurium hexafluoride	tert-Butyl isocyanate
	n-Octyl mercaptan	Tetraethyl lead
	Titanium tetrachloride	Tetraethyl pyroposphate
	Trichloroacetyl chloride	Tetramethyl lead
	Trifluoroacetyl chloride	Toluene 2,4-diisocyanate
		Toluene 2,6-diisocyanate

Source: http://www.ncjrs.gov/pdffiles1/nij/1844491.p2df (National Institute of Justice, June, 2000

Annexure-IV

Maximum allowable limit for water poisons (chemical agents)

Contaminant	Canadian Limits* (mg/L)	US Limits ** (mg/L)	WHO Limits *** (mg/L)	Detection limit of Indigenous Water Poison Detection Kit (mg/L)
Aluminum	0.1	0.05 - 0.2	no limit listed	-
Antimony	0.006	0.006	0.018	-
Arsenic	0.010	0.010	0.01	0.2
Asbestos	-	7 million fibers per liter	no limit listed	-
Barium	1.00	2	0.7	-
Beryllium	no limit listed	0.004	no limit listed	-
Boron	5.00	no limit listed	0.5	-
Bromate	0.01	0.010	0.010	-
Cadmium	0.005	0.005	0.003	-
Calcium	200	-	-	-
Chloramines	3.0	-	3	-
Chloride	less than 251	-	no limit listed	-
Chlorite	-	1.0	-	-
Chromium	0.050	0.01	0.05	-
Cobalt	no limit listed	-	-	-
Copper	1.0	1.3	2	1.5
Cyanide	0.2	0.2	0.07	0.05
Fluoride	1.5	4.0	1.5	-
Gold	no limit listed	-	-	-
Iron	0.300	0.3	no limit listed	-
Lanthanum	no limit listed	-	-	-
Lead	0.010	0	0.001	0.001
Magnesium	50.0	-	-	
Manganese	0.050	0.03	0.4	0.2
Mercury	0.001	0.002	0.001	0.5
Molybdenum	0.25	-	0.07	-
Nickel	no limit listed	-	0.020	-
Nitrate	45	10	-	-
Nitrite	-	1	-	-
Phosphorus	0.010	-	-	-
Potassium	no limit listed	-	-	-
Scandium	no limit listed	-	-	-
Selenium	0.01	0.05	0.01	-

Silicon	no limit listed	-	-	-
Silver	0.050	0.10	no limit listed	-
Sodium	200	no limit listed	no limit listed	-
Strontium	no limit listed	-	-	-
Sulphate	500	-	500	-
Sulphide	-	-	-	-
Thallium	-	0.002	-	-
Titanium	no limit listed	-	-	-
Trichloroethylene (TCE)	0.005	-	-	-
Trihalomethanes (total)^^	0.1	0.1	1	-
Tungsten	no limit listed	-	-	-
Uranium	0.02	-	0.009	-
Vanadium	no limit listed	no limit listed	-	-
Zinc	5.00	5	no limit listed	-
Soamn, Sarin, Tabun, Vx (Nerve agents)	-	-		0.01
Sulphur Mustard (Blister agent)	-	-		2.0

Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million.

Annexure-V

Waterborne Pathogens and Their Significance in Water Supplies

Pathogen	Health significance[b]	Persistence in water supplies[c]	Resistance to chlorine[d]	Relative infectivity[e]	Important animal source
Bacteria					
Burkholderia pseudomallei	High	May multiply	Low	Low	No
Campylobacter jejuni, C. coli	High	Moderate	Low	Moderate	Yes
Escherichia coli – Pathogenic[f]	High	Moderate	Low	Low	Yes
E. coli – Enterohaemorrhagic	High	Moderate	Low	High	Yes
Legionella spp.	High	May multiply	Low	Moderate	No
Non-tuberculous mycobacteria	Low	May multiply	High	Low	No
Pseudomonas aeruginosa[g]	Moderate	May multiply	Moderate	Low	No
Salmonella typhi	High	Moderate	Low	Low	No
Other salmonellae	High	May multiply	Low	Low	Yes
Shigella spp.	High	Short	Low	High	No
Vibrio cholerae	High	Short to long[h]	Low	Low	No
Yersinia enterocolitica	Moderate	Long	Low	Low	Yes
Viruses					
Adenoviruses	Moderate	Long	Moderate	High	No
Enteroviruses	High	Long	Moderate	High	No
Astroviruses	Moderate	Long	Moderate	High	No
Hepatitis A virus	High	Long	Moderate	High	No
Hepatitis E virus	High	Long	Moderate	High	Potentially
Noroviruses	High	Long	Moderate	High	Potentially
Sapoviruses	High	Long	Moderate	High	Potentially
Rotavirus	High	Long	Moderate	High	No
Protozoa					
Acanthamoeba spp.	High	May multiply	Low	High	No
Cryptosporidium parvum	High	Long	High	High	Yes
Cyclospora cayetanensis	High	Long	High	High	No
Entamoeba histolytica	High	Moderate	High	High	No
Giardia intestinalis	High	Moderate	High	High	Yes
Naegleria fowleri	High	May multiply[i]	Low	Moderate	No
Toxoplasma gondii	High	Long	High	High	Yes
Helminths					
Dracunculus medinensis	High	Moderate	Moderate	High	No
Schistosoma spp.	High	Short	Moderate	High	Yes

a This table contains pathogens for which there is some evidence of health significance related to their occurrence in drinking-water supplies.

b Health significance relates to the severity of impact, including association with outbreaks.

c Detection period for infective stage in water at 20° C: short, up to 1 week; moderate, 1 week to 1 month; long, over 1 month.

d When the infective stage is freely suspended in water treated at conventional doses and contact times and pH between 7 and 8. Low means 99% inactivation at 20° C generally in <1 min, moderate 1–30 min and high >30 min. It should be noted that organisms that survive and grow in biofilms, such as Legionella and mycobacteria, will be protected from chlorination.

e From experiments with human volunteers, from epidemiological evidence and from animal studies. High means infective doses can be 1–102 organisms or particles, moderate 102–104 and low >104.

f Includes enteropathogenic, enterotoxigenic and enteroinvasive.

g Main route of infection is by skin contact, but can infect immune-suppressed or cancer patients orally.

h Vibrio cholerae may persist for long periods in association with copepods and other aquatic organisms.

i In warm water.

Source: WHO Guideline for drinking water Quality, Third Edition 2004.

Annexure-VI

Vulnerability Assessment Questioners

General Questions for the Entire Water System

The first 13 questions in this vulnerability self-assessment are general questions designed to apply to all components of your system (wellhead or surface water intake, treatment plant, storage tank(s), pumps, distribution system, and offices). These are followed by more specific questions that look at individual system components in greater detail.

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
1. Do you have a written emergency response plan (ERP)?	Yes • No •	It is essential that you have an ERP. If you do not have an ERP, you can obtain a sample from your state drinking water primacy agency. As a first step in developing your ERP, you should develop your Emergency Contact List (see Attachment 2). A plan is vital in case there is an incident that requires immediate response. Your plan should be reviewed at least annually (or more frequently if necessary) to ensure it is up-to-date and addresses security emergencies. You should designate someone to be contacted in case of emergency regardless of the day of the week or time of day. This contact information should be kept up-to-date and made available to all water system personnel and local officials (if applicable). Share this ERP with police, emergency personnel, and your state primacy agency. Posting contact information is a good idea only if authorized personnel are the only ones seeing the information. These signs could pose a security risk if posted for public viewing since it gives people information that could be used against the system.	
2. Is access to the critical components of the water system (i.e., a part of the physical infrastructure of the system that is essential for water flow and/or water quality) restricted to authorized personnel only?	Yes • No •	You should restrict or limit access to the critical components of your water system to authorized personnel only. This is the first step in security enhancement for your water system. Consider the following: • Issue water system photo identification cards for employees, and require them to be displayed within the restricted area at all times. • Post signs restricting entry to authorized personnel and ensure that assigned staff escort people without proper ID.	

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
3. Are facilities fenced, including wellhouses and pump pits, and are gates locked where appropriate?	Yes • No •	Ideally, all facilities should have a security fence around the perimeter. The fence perimeter should be walked periodically to check for breaches and maintenance needs. All gates should be locked with chains and a tamper-proof padlock that at a minimum protects the shank. Other barriers such as concrete "jersey" barriers should be considered to guard certain critical components from accidental or intentional vehicle intrusion.	
4. Are your doors, windows, and other points of entry such as tank and roof hatches and vents kept closed and locked?	Yes • No •	Lock all building doors and windows, hatches and vents, gates, and other points of entry to prevent access by unauthorized personnel. Check locks regularly. Dead bolt locks and lock guards provide a high level of security for the cost. A daily check of critical system components enhances security and ensures that an unauthorized entry has not taken place. Doors and hinges to critical facilities should be constructed of heavy-duty reinforced material. Hinges on all outside doors should be located on the inside. To limit access to water systems, all windows should be locked and reinforced with wire mesh or iron bars, and bolted on the inside. Systems should ensure that this type of security meets with the requirements of any fire codes. Alarms can also be installed on windows, doors, and other points of entry.	
5. Is there external lighting around the critical components of your water system?	Yes • No •	Adequate lighting of the exterior of water systems' critical components is a good deterrent to unauthorized access and may result in the detection or deterrence of trespassers. Motion detectors that activate switches that turn lights on or trigger alarms also enhance security.	
6. Are warning signs (tampering, unauthorized access, etc.) posted on all critical components of your water system? (For example, well houses and storage tanks.)	Yes • No •	Warning signs are an effective means to deter unauthorized access. "Warning - Tampering with this facility is a federal offense" should be posted on all water facilities. These are available from your state rural water association. "Authorized Personnel Only," "Unauthorized Access Prohibited," and "Employees Only" are examples of other signs that may be useful.	
7. Do you patrol and inspect your source intake, buildings, storage tanks, equipment, and other critical components?	Yes • No •	Frequent and random patrolling of the water system by utility staff may discourage potential tampering. It may also help identify problems that may have arisen since the previous patrol. Consider asking your local law enforcement agencies to conduct patrols of your water system. Advise them of your critical components and explain why they are important.	

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
8. Is the area around the critical components of your water system free of objects that may be used for breaking and entering?	Yes • No •	When assessing the area around your water system's critical components, look for objects that could be used to gain entry (e.g., large rocks, cement blocks, pieces of wood, ladders, valve keys, and other tools).	
9. Are the entry points to your water system easily seen?	Yes • No •	You should clear fence lines of all vegetation. Overhanging or nearby trees may also provide easy access. Avoid landscaping that will permit trespassers to hide or conduct unnoticed suspicious activities. Trim trees and shrubs to enhance the visibility of your water system's critical components. If possible, park vehicles and equipment in places where they do not block the view of your water system's critical components.	
10. Do you have an alarm system that will detect unauthorized entry or attempted entry at critical components?	Yes • No •	Consider installing an alarm system that notifies the proper authorities or your water system's designated contact for emergencies when there has been a breach of security. Inexpensive systems are available. An alarm system should be considered whenever possible for tanks, pump houses, and treatment facilities. You should also have an audible alarm at the site as a deterrent and to notify neighbors of a potential threat.	
11. Do you have a key control and accountability policy?	Yes • No •	Keep a record of locks and associated keys, and to whom the keys have been assigned. This record will facilitate lock replacement and key management (e.g., after employee turnover or loss of keys). Vehicle and building keys should be kept in a lockbox when not in use. You should have all keys stamped (engraved) "DO NOT DUPLICATE."	
12. Are entry codes and keys limited to water system personnel only?	Yes • No •	Suppliers and personnel from co-located organizations (e.g., organizations using your facility for telecommunications) should be denied access to codes and/or keys. Codes should be changed frequently if possible. Entry into any building should always be under the direct control of water system personnel.	
13. Do you have a neighborhood watch program for your water system?	Yes • No •	Watchful neighbors can be very helpful to a security program. Make sure they know whom to call in the event of an emergency or suspicious activity.	

Water Sources

In addition to the above general checklist for your entire water system (questions 1-13), you should give special attention to the following issues, presented in separate tables, related to various water system components. Your water sources (surface water intakes or wells) should be secured. Surface water supplies present the greatest challenge. Typically they encompass large land areas. Where areas cannot be secured, steps should be taken to initiate or increase law enforcement patrols. Pay particular attention to surface water intakes. Ask the public to be vigilant and report suspicious activity.

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
14. Are your wellheads sealed properly?	Yes • No •	A properly sealed wellhead decreases the opportunity for the introduction of contaminants. If you are not sure whether your wellhead is properly sealed, contact your well drilling/maintenance company, your state drinking water primacy agency, your state rural water association, or other technical assistance providers.	
15. Are well vents and caps screened and securely attached?	Yes • No •	Properly installed vents and caps can help prevent the introduction of a contaminant into the water supply. Ensure that vents and caps serve their purpose, and cannot be easily breached or removed.	
16. Are observation/test and abandoned wells properly secured to prevent tampering?	Yes • No •	All observation/test and abandoned wells should be properly capped or secured to prevent the introduction of contaminants into the aquifer or water supply. Abandoned wells should be either removed or filled with concrete.	
17. Is your surface water source secured with fences or gates? Do water system personnel visit the source?	Yes • No •	Surface water supplies present the greatest challenge to secure. Often, they encompass large land areas. Where areas cannot be secured, steps should be taken to initiate or increase patrols by water utility personnel and law enforcement agents.	

Treatment Plant and Suppliers

Some small systems provide easy access to their water system for suppliers of equipment, chemicals, and other materials for the convenience of both parties. This practice should be discontinued.

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
18. Are deliveries of chemicals and other supplies made in the presence of water system personnel?	Yes • No •	Establish a policy that an authorized person, designated by the water system, must accompany all deliveries. Verify the credentials of all drivers. This prevents unauthorized personnel from having access to the water system.	
19. Have you discussed with your supplier(s) procedures to ensure the security of their products?	Yes • No •	Verify that your suppliers take precautions to ensure that their products are not contaminated. Chain of custody procedures for delivery of chemicals should be reviewed. You should inspect chemicals and other supplies at the time of delivery to verify they are sealed and in unopened containers. Match all delivered goods with purchase orders to ensure that they were, in fact, ordered by your water system. You should keep a log or journal of deliveries. It should include the driver's name (taken from the driver's photo I.D.), date, time, material delivered, and the supplier's name.	

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
20. Are chemicals, particularly those that are potentially hazardous or flammable, properly stored in a secure area?	Yes • No •	All chemicals should be stored in an area designated for their storage only, and the area should be secure and access to the area restricted. Access to chemical storage should be available only to authorized employees. You should have tools and equipment on site (such as a fire extinguisher, drysweep, etc.) to take immediate actions when responding to an emergency.	
21. Do you monitor raw and treated water so that you can detect changes in water quality?	Yes • No •	Monitoring of raw and treated water can establish a baseline that may allow you to know if there has been a contamination incident. Some parameters for raw water include pH, turbidity, total and fecal coliform, total organic carbon, specific conductivity, ultraviolet adsorption, color, and odor. Routine parameters for finished water and distribution systems include free and total chlorine residual, heterotrophic plate count (HPC), total and fecal coliform, pH, specific conductivity, color, taste, odor, and system pressure. Chlorine demand patterns can help you identify potential problems with your water. A sudden change in demand may be a good indicator of contamination in your system. For those systems that use chlorine, absence of a chlorine residual may indicate possible contamination. Chlorine residuals provide protection against bacterial and viral contamination that may enter the water supply.	
22. Are tank ladders, access hatches, and entry points secured?	Yes • No •	The use of tamper-proof padlocks at entry points (hatches, vents, and ladder enclosures) will reduce the potential for of unauthorized entry. If you have towers, consider putting physical barriers on the legs to prevent unauthorized climbing.	
23. Are vents and overflow pipes properly protected with screens and/or grates?	Yes • No •	Air vents and overflow pipes are direct conduits to the finished water in storage facilities. Secure all vents and overflow pipes with heavy-duty screens and/or grates.	
24. Can you isolate the storage tank from the rest of the system?	Yes • No •	A water system should be able to take its storage tank(s) out of operation or drain its storage tank(s) if there is a contamination problem or structural damage. Install shut-off or bypass valves to allow you to isolate the storage tank in the case of a contamination problem or structural damage. Consider installing a sampling tap on the storage tank outlet to test water in the tank for possible contamination.	

Distribution

Hydrants are highly visible and convenient entry points into the distribution system. Maintaining and monitoring positive pressure in your system is important to provide fire protection and prevent introduction of contaminants.

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
25. Do you control the use of hydrants and valves?	Yes • No •	Your water system should have a policy that regulates the authorized use of hydrants for purposes other than fire protection. Require authorization and backflow devices if a hydrant is used for any purpose other than fire fighting. Consider designating specific hydrants for use as filling station(s) with proper backflow prevention (e.g., to meet the needs of construction firms). Then, notify local law enforcement officials and the public that these are the only sites designated for this use. Flush hydrants should be kept locked to prevent contaminants from being introduced into the distribution system, and to prevent improper use.	
26. Does your system monitor for, and maintain, positive pressure?	Yes • No •	Positive pressure is essential for fire fighting and for preventing backsiphonage that may contaminate finished water in the distribution system. Refer to your state primacy agency for minimum drinking water pressure requirements.	
27. Has your system implemented a backflow prevention program?	Yes • No •	In addition to maintaining positive pressure, backflow prevention programs provide an added margin of safety by helping to prevent the intentional introduction of contaminants. If you need information on backflow prevention programs, contact your state drinking water primacy agency.	

Personnel

You should add security procedures to your personnel policies.

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
28. When hiring personnel, do you request that local police perform a criminal background check, and do you verify employment eligibility (as required by the Immigration and Naturalization Service, Form I-9)?	Yes • No •	It is good practice to have all job candidates fill out an employment application. You should verify professional references. Background checks conducted during the hiring process may prevent potential employee-related security issues. If you use contract personnel, check on the personnel practices of all providers to ensure that their hiring practices are consistent with good security practices.	

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
29. Are your personnel issued photo-identification cards?	Yes • No •	For positive identification, all personnel should be issued water system photo-identification cards and be required to display them at all times. Photo identification will also facilitate identification of authorized water system personnel in the event of an emergency.	
30. When terminating employment, do you require employees to turn in photo IDs, keys, access codes, and other security-related items?	Yes • No •	Former or disgruntled employees have knowledge about the operation of your water system, and could have both the intent and physical capability to harm your system. Requiring employees who will no longer be working at your water system to turn in their IDs, keys, and access codes helps limit these types of security breaches.	
31. Do you use uniforms and vehicles with your water system name prominently displayed?	Yes • No •	Requiring personnel to wear uniforms, and requiring that all vehicles prominently display the water system name, helps inform the public when water system staff is working on the system. Any observed activity by personnel without uniforms should be regarded as suspicious. The public should be encouraged to report suspicious activity to law enforcement authorities.	
32. Have water system personnel been advised to report security vulnerability concerns and to report suspicious activity?	Yes • No •	Your personnel should be trained and knowledgeable about security issues at your facility, what to look for, and how to report any suspicious events or activity. Periodic meetings of authorized personnel should be held to discuss security issues.	
33. Do your personnel have a checklist to use for threats or suspicious calls or to report suspicious activity?	Yes • No •	To properly document suspicious or threatening phone calls or reports of suspicious activity, a simple checklist can be used to record and report all pertinent information. Calls should be reported immediately to appropriate law enforcement officials. Checklists should be available at every telephone. Sample checklists are included in Attachment 3. Also consider installing caller ID on your telephone system to keep a record of incoming calls.	

Information storage/computers/controls/maps

Security of the system, including computerized controls like a Supervisory Control and Data Acquisition (SCADA) system, goes beyond the physical aspects of operation. It also includes records and critical information that could be used by someone planning to disrupt or contaminate your water system.

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
34. Is computer access "password protected?" Is virus protection installed and software upgraded regularly and are your virus definitions updated at least daily? Do you have Internet firewall software installed on your computer? Do you have a plan to back up your computers?	Yes • No •	All computer access should be password protected. Passwords should be changed every 90 days and (as needed) following employee turnover. When possible, each individual should have a unique password that they do not share with others. If you have Internet access, a firewall protection program should be installed on your computer. Also consider contacting a virus protection company and subscribing to a virus update program to protect your records. Backing up computers regularly will help prevent the loss of data in the event that your computer is damaged or breaks. Backup copies of computer data should be made routinely and stored at a secure off-site location.	

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
35. Is there information on the Web that can be used to disrupt your system or contaminate your water?	Yes • No •	Posting detailed information about your water system on a Web site may make the system more vulnerable to attack. Web sites should be examined to determine whether they contain critical information that should be removed. You should do a Web search (using a search engine such as Google, Yahoo!, or Lycos) using key words related to your water supply to find any published data on the Web that is easily accessible by someone who may want to damage your water supply.	
36. Are maps, records, and other information stored in a secure location?	Yes • No •	Records, maps, and other information should be stored in a secure location when not in use. Access should be limited to authorized personnel only. You should make back-up copies of all data and sensitive documents. These should be stored in a secure off-site location on a regular basis.	
37. Are copies of records, maps, and other sensitive information labeled confidential, and are all copies controlled and returned to the water system?	Yes • No •	Sensitive documents (e.g., schematics, maps, and plans and specifications) distributed for construction projects or other uses should be recorded and recovered after use. You should discuss measures to safeguard your documents with bidders for new projects.	
38. Are vehicles locked and secured at all times?	Yes • No •	Vehicles are essential to any water system. They typically contain maps and other information about the operation of the water system. Water system personnel should exercise caution to ensure that this information is secure. Water system vehicles should be locked when they are not in use or left unattended. Remove any critical information about the system before parking vehicles for the night. Vehicles also usually contain tools (e.g., valve wrenches) that could be used to access critical components of your water system. These tools should be secured and accounted for daily.	

Public Relations

You should educate your customers about your system. You should encourage them to be alert and to report any suspicious activity to law enforcement authorities.

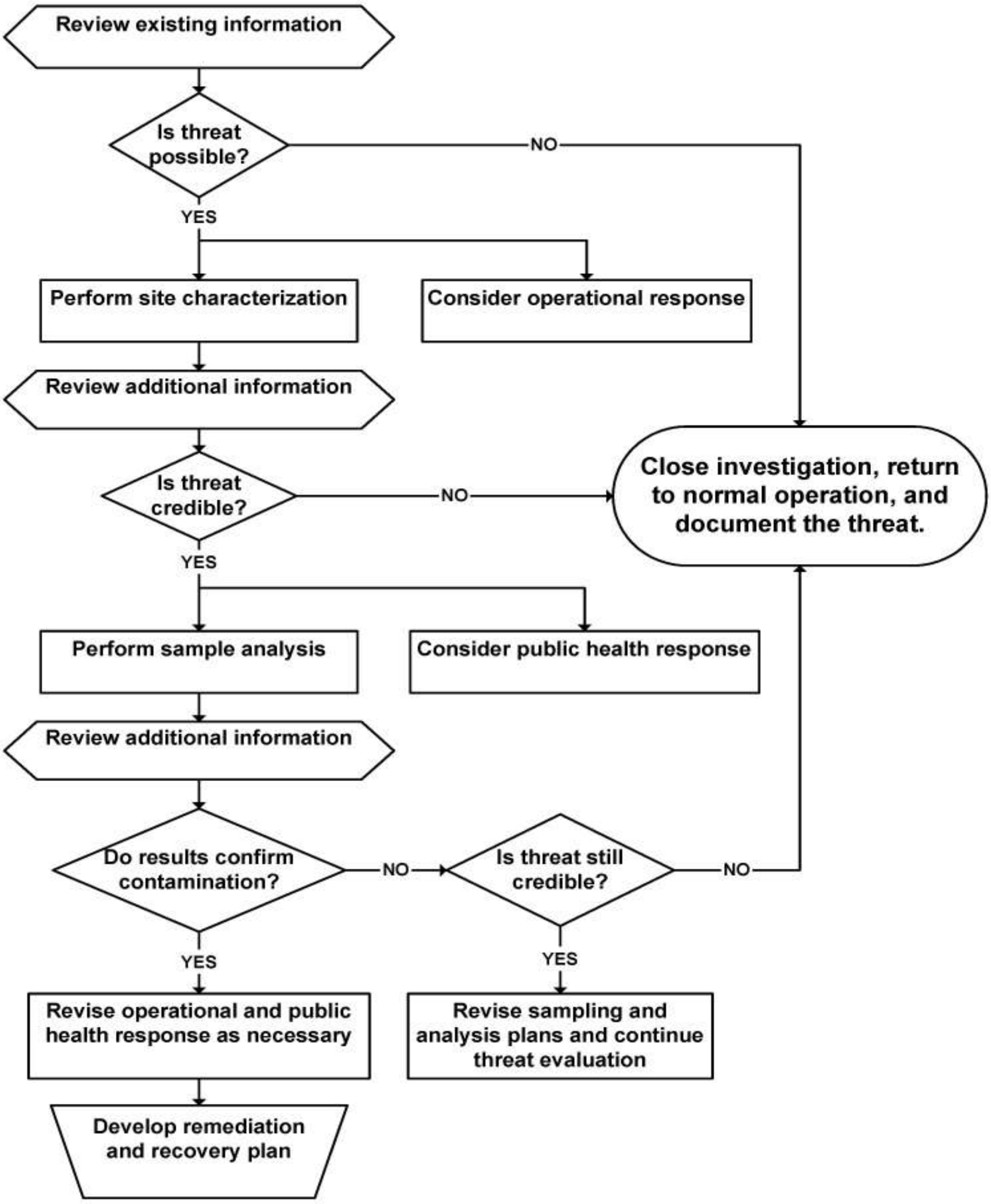
QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
39. Do you have a program to educate and encourage the public to be vigilant and report suspicious activity to assist in the security protection of your water system?	Yes • No •	Advise your customers and the public that your system has increased preventive security measures to protect the water supply from vandalism. Ask for their help. Provide customers with your telephone number and the telephone number of the local law enforcement authority so that they can report suspicious activities. The telephone number can be made available through direct mail, billing inserts, notices on community bulletin boards, flyers, and consumer confidence reports.	

QUESTION	ANSWER	COMMENT	ACTION NEEDED/TAKEN
40. Does your water system have a procedure to deal with public information requests, and to restrict distribution of sensitive information?	Yes • No •	You should have a procedure for personnel to follow when you receive an inquiry about the water system or its operation from the press, customers, or the general public. Your personnel should be advised not to speak to the media on behalf of the water system. Only one person should be designated as the spokesperson for the water system. Only that person should respond to media inquiries. You should establish a process for responding to inquiries from your customers and the general public.	
41. Do you have a procedure in place to receive notification of a suspected outbreak of a disease immediately after discovery by local health agencies?	Yes • No •	It is critical to be able to receive information about suspected problems with the water at any time and respond to them quickly. Procedures should be developed in advance with your state drinking water primacy agency, local health agencies, and your local emergency planning committee.	
42. Do you have a procedure in place to advise the community of contamination immediately after discovery?	Yes • No •	As soon as possible after a disease outbreak, you should notify testing personnel and your laboratory of the incident. In outbreaks caused by microbial contaminants, it is critical to discover the type of contaminant and its method of transport (water, food, etc.). Active testing of your water supply will enable your laboratory, working in conjunction with public health officials, to determine if there are any unique (and possibly lethal) disease organisms in your water supply. It is critical to be able to get the word out to your customers as soon as possible after discovering a health hazard in your water supply. In addition to your responsibility to protect public health, you must also comply with the requirements of the Public Notification Rule. Some simple methods include announcements via radio or television, door-to-door notification, a phone tree, and posting notices in public places. The announcement should include accepted uses for the water and advice on where to obtain safe drinking water. Call large facilities that have large populations of people who might be particularly threatened by the outbreak: hospitals, nursing homes, the school district, jails, large public buildings, and large companies. Enlist the support of local emergency response personnel to assist in the effort.	
43. Do you have a procedure in place to respond immediately to a customer complaint about a new taste, odor, color, or other physical change (oily, filmy, burns on contact with skin)?	Yes • No •	It is critical to be able to respond to and quickly identify potential water quality problems reported by customers. Procedures should be developed in advance to investigate and identify the cause of the problem, as well as to alert local health agencies, your state drinking water primacy agency, and your local emergency planning committee if you discover a problem.	

Source: Environment Protection Agency, USA

Annexure-VII

Threat Evaluation Matrix



Source: Emergency response planning guidance For Kansas Public Water Supply Systems.

Annexure-VIII

Threat Evaluation Worksheet

THREAT WARNING INFORMATION

Date/Time threat warning discovered: ____________________________

Utility Name and Address: ____________________________

Name/Number of person who discovered threat warning: ____________________________

Type of threat warning:

☐ Security breach ☐ Witness account ☐ Phone threat
☐ Written threat ☐ Unusual water quality ☐ Consumer complaints
☐ Public health notification ☐ Other ____________________________

Identity of the contaminant: ☐ Known ☐ Suspected ☐ Unknown
If known or suspected, provide additional detail below

☐ Chemical ☐ Biological ☐ Radiological

Describe ____________________________

____

Time of contamination: ☐ Known ☐ Estimated ☐ Unknown
If known or estimated, provide additional detail below

Date and time of contamination: ____________________________

Additional Information: ____________________________

____

Mode of contamination: ☐ Known ☐ Suspected ☐ Unknown
If known or suspected, provide additional detail below

Method of addition: ☐ Single dose ☐ Over time ☐ Other ____________

Amount of material: ____________________________

Additional Information: ____________________________

____

Site of contamination: ☐ Known ☐ Suspected ☐ Unknown

If known or suspected, provide additional detail below

Number of sites: ____________________

Provide the following information for each site.

Site #1

Site Name: ____________________

Type of facility

☐ Source water	☐ Treatment plant	☐ Pump station
☐ Ground storage tank	☐ Elevated storage tank	☐ Finished water reservoir
☐ Distribution main	☐ Hydrant	☐ Service connection
☐ Other ____________________		

Address: ____________________

____

Additional Site Information: ____________________

____

Site #2

Site Name: ____________________

Type of facility

☐ Source water	☐ Treatment plant	☐ Pump station
☐ Ground storage tank	☐ Elevated storage tank	☐ Finished water reservoir
☐ Distribution main	☐ Hydrant	☐ Service connection
☐ Other ____________________		

Address: ____________________

____

Additional Site Information: ____________________

____

Site #3

Site Name: ____________________

Type of facility

☐ Source water	☐ Treatment plant	☐ Pump station
☐ Ground storage tank	☐ Elevated storage tank	☐ Finished water reservoir
☐ Distribution main	☐ Hydrant	☐ Service connection
☐ Other ____________________		

Address: ____________________

____

Additional Site Information: ____________________

____

ADDITIONAL INFORMATION

Has there been a breach of security at the suspected site? ☐ Yes ☐ No
If "Yes", review the completed 'Security Incident Report' (Section 2.4)

Are there any witness accounts of the suspected incident? ☐ Yes ☐ No
If "Yes", review the completed 'Witness Account Report' (Section 2.5)

Was the threat made verbally over the phone? ☐ Yes ☐ No
If "Yes", review the completed 'Phone Threat Report' (Section 2.6)

Was a written threat received? ☐ Yes ☐ No
If "Yes", review the completed 'Written Threat Report' (Section 2.7)

Are there unusual water quality data or consumer complaints? ☐ Yes ☐ No
If "Yes", review the completed 'Water Quality/Consumer Complaint Report' (Section 2.8)

Are there unusual symptoms or disease in the population? ☐ Yes ☐ No
If "Yes", review the completed 'Public Health Report' (Section 2.9)

Is a 'Site Characterization Report' available? ☐ Yes ☐ No
If "Yes", review the completed 'Site Characterization Report' (Section 3.4)

Are results of sample analysis available? ☐ Yes ☐ No
If "Yes", review the analytical results report, including appropriate QA/QC data

Is a 'Contaminant Identification Report' available? ☐ Yes ☐ No
If "Yes", review the completed 'Sample Analysis Report' (Section 4.3)

Is there relevant information available from external sources? ☐ Yes ☐ No
Check all that apply

☐ Local law enforcement ☐ FBI ☐ DW primacy agency
☐ Public health agency ☐ Hospitals / 911 call centers ☐ US EPA / Water ISAC
☐ Media reports ☐ Homeland security alerts ☐ Neighboring utilities
☐ Other ________________________________

Point of Contact: ________________________________

____

Summary of key information from external sources (provide detail in attachments as necessary):

____

____

____

____

____

____

Source: Emergency response planning guidance For Kansas public water supply systems.

Annexure-IX

Sample Collection Guideline

For the purpose of this guideline, two general classes of samples are considered:

a. Environmental Samples

b. Hazardous Samples

a. **Environmental Samples** are those collected from environmental media, such as natural or treated waters, and are not expected to be contaminated with hazardous materials at concentrations which would pose a risk to unprotected personnel. The vast majority of water samples collected is expected to be classified as Environmental Samples.

The two most common types of Environmental Samples are grab samples and composite samples. A grab sample is a single sample collected at a particular time and place that represents the composition of the water only at that time and location. The sample is collected all at once and at one particular point in the sample medium. A composite sample is composed of several smaller sample amounts collected at various sample locations and/or different points in time, which are then combined to form one composite sample. Analysis of a composite sample produces an average value and can, in certain instances, be used as an alternative to analyzing a number of individual grab samples and calculating an average value.

b. **Hazardous Samples** typically consist of concentrated hazardous materials. A hazardous sample would most likely be taken from a suspected source of contamination at a water utility such as from drums, tanks, lagoons, pits, waste piles, or fresh spills. *Accordingly, they require special handling procedures due to their potential toxicity or hazard*.

The objective of taking samples from a suspected contamination site or secondary investigation site is to obtain and preserve a sample of the water at a particular time and location, so that it can be analyzed later if necessary.

In order to perform sampling effectively, sampling requirements should be considered while formulating emergency response plan.

Factors to be considered during the development of a sampling approach include:

- Class or type of contaminant to be sampled.
- Place and time of samples to be collected.
- Special techniques or precautions necessary during sample collection.

Selection of target contaminants during development of a customized site characterization plan will be based on an initial assessment of information about the threat. Prior to site characterization, it is likely that little will be known about the identity of suspected water contaminants.

In this case, the sampling approach may need to be comprehensive and include all analytes covered by the sample kit. In some cases, the available information about the threat may indicate the presence of a particular contaminant or contaminant class, and the sample plan may be adjusted accordingly. However, during this initial stage of site characterization, it may still be prudent to plan to collect a complete sample set (i.e., all sample containers in the utility's emergency water sampling kit) from the investigation site.

Remember to identify labs well in advance and alert them that samples will be coming well ahead of time so they can begin to prepare for the analyses.

Sample Collection Kits

Sample collection kits will generally contain all sample containers, materials, supplies, and forms necessary to perform sample collection activities. Sample collection kits can be constructed and pre-positioned throughout a system to expedite the sampling process. They can also be standardized throughout an area to facilitate sharing of kits in the event of an emergency that requires extensive sampling. A standard sample collection kit includes:

- Large plastic container for holding sample kit supplies
- Field resources and documentation
- General sampling supplies, including sample containers
- Pathogen sampling supplies
- Reagents
- Safety supplies

Labeling: Each sample container should be properly labeled using a waterproof marker with the following information:

i) analysis

ii) preservative (if any)

iii) dechlorinating agent (if any)

iv) sample location

v) sample identification

vi) sample collection date and time

vii) sampler's initials

Additional information requested on the sample label should be provided as well. It is recommended that sample labels for each container be completed before beginning sample collection. Typically, it is done just before obtaining the sample, or the "time" is left blank and entered immediately after collecting the sample.

During routine drinking water sampling, containers are often taken into the field with preservatives already in them. Samplers need to determine in advance if "pre-preservation" of containers is appropriate.

Sampling Procedures for Microbiological Contaminants: Important safety precautions for all microbial contaminants. Safety glasses must be worn. Wash hands before and after sampling. The use of clean, powder-free nitrile gloves is strongly recommended. Do not collect samples with exposed skin on hands.

1. Avoid splashing or aerosolizing water droplets during sample collection or field concentration.

2. Do not rinse or overfill the sample containers. This is especially important if the sample container contains a preservative or dechlorinating agent. Do not use rubber or plastic tubing for the collection of samples.
3. Any sample collected for culture analysis should be handled in a manner such that viability of the microorganisms is maintained.
4. If necessary, add any preservatives and/or dechlorinating agents. Preservatives and/or dechlorinating agents may be added to the sample containers during sample kit preparation, which can significantly decrease the complexity and time required for sample collection.
5. Wipe the outside of the sealed containers with an aseptic wipe or a mild bleach solution.
6. Attach custody seal to the individual sample container, if required by the organization responsible for sample collection and handling. In some cases, it may be sufficient to place the custody seal on the shipping container rather than the individual sample containers themselves. Record the information in a Custody record.
7. Place the sample container into a sealable plastic bag (bubble wrap baggies can provide protection against breakage of glass sample containers).
8. Place the sealed plastic bags containing the samples into an appropriate, rigid, shipping container and pack with frozen ice packs (preferred) or sealable freezer bags filled with ice. If ice is used, the bag should be thoroughly sealed and double bagged to avoid leakage. See Section 6 for more details on sample packaging in coolers and shipment.

Source: *'Sampling Guide for First Responders to Drinking Water Contamination Threats and Incidents'*, New England Water Works Association (USA)

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Annexure-X

Laboratory Identification of Biological Warfare Agents

Disease/ Agent	Gold Standard	Antigen Detection	IgG	IgM	PCR	Animal
Aflatoxin Aflatoxins	Mass Spectrometry	X				
Anthrax *Bacillus anthracis*	FA/Std. Microbiology	X	X	X	X	X
Brucellosis *Brucella sp.*	FA/Std. Microbiology	X	X	X	X	X
Cholera *Vibrio cholerae*	Std. Microbiology /Serology	X(toxin)	X	X	X	
Glanders *B. mallei*	Std. Microbiology		X	X	X	
B. pseudomallei	Std. Microbiology		X	X	X	
Plague *Yersinia pestis*	FA/Std. Microbiology	X	X	X	X	X
Tularemia *F. tularensis*	FA/Std. Microbiology	X	X	X	X	X
Q Fever *C. burnetii*	FA/Eggs or Cell Cx/ Serology	X	X	X	X	X
Smallpox Orthopox Viruses	Virus Isolation/ FA /Neutralization	X	X		X	X
Venezuelan Equine Encephalitis Arboviruses (incl. Alphaviruses	Virus Isolation/FA, Neutralization	X	X	X	X	X
Viral Hemorrhagic Fevers Filoviruses	Virus Isolation /Neutralization	X	X	X	X	X
Hantaviruses	Virus Isolation/ FA/ Neutralization	X	X	X	X	X
Botulism Bot Toxins (A-G)/*C. botulinum*	Mouse Neutralization/ Standard Microbiology	X			*	X
Saxitoxin Saxitoxin	Bioassay		(neutralizing antibodies)		X	
Shigellosis *Shigella sp.*	Std. Microbiology	X			X	

Staph Enterotoxin B SEB Toxin	ELISA	X	X		*	X
Ricin Ricin Toxin	ELISA	X	X	X	X	X
T-2 Mycotoxins T-2 Mycotoxins	Mass Spectrometry	X				
Tetrodototoxin Tetrodotoxins	Bioassay	X	(neutralizing antibodies))			X
C. perfringens/Toxins	Std. Micro./ELISA (Alpha & Enterotoxin)	X	X		X	

* Toxin gene detected — only works if cellular debris including genes present as contaminant. Purified toxin does not contain detectable genes.

ELISA — enzyme-linked immunosorbent assays.

FA — indirect or direct immunofluorescence assays.

Std. Micro./serology — standard microbiological techniques available, including electron microscopy. Not all assays are available in field laboratories.

X — Advisable.

Annexure-XI

Reductions of Bacteria, Viruses and Protozoa Achieved By Typical and Enhanced Water Treatment Processes

Treatment process	Enteric pathogen group	Baseline removal	Maximum removal possible
Pretreatment			
Roughing filters	Bacteria	50%	Up to 95% if protected from turbidity spikes by dynamic filter or if used only when ripened
	Viruses	No data available	
	Protozoa	No data available, some removal likely	Performance for protozoan removal likely to correspond to turbidity removal
Microstraining	Bacteria, viruses, protozoa	Zero	Generally ineffective
Off-stream/ bankside storage	All	Recontamination may be significant and add to pollution levels in incoming water; growth of algae may cause deterioration in quality	Avoiding intake at periods of peak turbidity equivalent to 90% removal; compartmentalized storages provide 15–230 times rates of removal
	Bacteria	Zero (assumes short circuiting)	90% removal in 10–40 days actual detention time
	Viruses	Zero (assumes short circuiting)	93% removal in 100 days actual detention time
	Protozoa	Zero (assumes short circuiting)	99% removal in 3 weeks actual detention time
Bankside infiltration	Bacteria	99.9% after 2 m 99.99% after 4 m (minimum based on virus removal)	
	Viruses	99.9% after 2 m 99.99% after 4 m	
	Protozoa	99.99%	
Coagulation/flocculation/sedimentation			
Conventional clarification	Bacteria	30%	90% (depending on the coagulant, pH, temperature, alkalinity, turbidity)
	Viruses	30%	70% (as above)
	Protozoa	30%	90% (as above)
High-rate clarification	Bacteria	At least 30%	
	Viruses	At least 30%	
	Protozoa	95%	99.99% (depending on use of appropriate blanket polymer)
Dissolved air flotation	Bacteria	No data available	
	Viruses	No data available	
	Protozoa	95%	99.9% (depending on pH, coagulant dose, flocculation time, recycle ratio)

Treatment process	Enteric pathogen group	Baseline removal	Maximum removal possible
Lime softening	Bacteria	20% at pH 9.5 for 6 h at 2–8 °C	99% at pH 11.5 for 6 h at 2–8 °C
	Viruses	90% at pH < 11 for 6 h	99.99% at pH > 11, depending on the virus and on settling time
	Protozoa	Low inactivation	99% through precipitative sedimentation and inactivation at pH 11.5
Ion exchange			
	Bacteria	Zero	
	Viruses	Zero	
	Protozoa	Zero	
Filtration			
Granular high-rate filtration	Bacteria	No data available	99% under optimum coagulation conditions
	Viruses	No data available	99.9% under optimum coagulation conditions
	Protozoa	70%	99.9% under optimum coagulation conditions
Slow sand filtration	Bacteria	50%	99.5% under optimum ripening, cleaning and refilling and in the absence of short circuiting
	Viruses	20%	99.99% under optimum ripening, cleaning and refilling and in the absence of short circuiting
	Protozoa	50%	99% under optimum ripening, cleaning and refilling and in the absence of short circuiting
Precoat filtration, including diatomaceous earth and perlite	Bacteria	30–50%	96–99.9% using chemical pretreatment with coagulants or polymers
	Viruses	90%	98% using chemical pretreatment with coagulants or polymers
	Protozoa	99.9%	99.99%, depending on media grade and filtration rate
Membrane filtration – microfiltration	Bacteria	99.9–99.99%, providing adequate pretreatment and membrane integrity conserved	
	Viruses	<90%	
	Protozoa	99.9–99.99%, providing adequate pretreatment and membrane integrity conserved	
Membrane filtration – ultrafiltration,	Bacteria	Complete removal, providing adequate pretreatment and membrane integrity conserved	

Treatment process	Enteric pathogen group	Baseline removal	Maximum removal possible
nanofiltration and reverse osmosis	Viruses	Complete removal with nanofilters, with reverse osmosis and at lower pore sizes of ultrafilters, providing adequate pretreatment and membrane integrity conserved	
	Protozoa	Complete removal, providing adequate pretreatment and membrane integrity conserved	
Disinfection			
Chlorine	Bacteria	Ct_{99}: 0.08 mg·min/litre at 1–2 °C, pH 7; 3.3 mg·min/litre at 1–2 °C, pH 8.5	
	Viruses	Ct_{99}: 12 mg·min/litre at 0–5 °C; 8 mg·min/litre at 10 °C; both at pH 7–7.5	
	Protozoa	*Giardia* Ct_{99}: 230 mg·min/litre at 0.5 °C; 100 mg·min/litre at 10 °C; 41 mg·min/litre at 25 °C; all at pH 7–7.5 *Cryptosporidium* not killed	
Monochloramine	Bacteria	Ct_{99}: 94 mg·min/litre at 1–2 °C, pH 7; 278 mg·min/litre at 1–2 °C, pH 8.5	
	Viruses	Ct_{99}: 1240 mg·min/litre at 1 °C; 430 mg·min/litre at 15 °C; both at pH 6–9	
	Protozoa	*Giardia* Ct_{99}: 2550 mg·min/litre at 1 °C; 1000 mg·min/litre at 15 °C; both at pH 6–9 *Cryptosporidium* not inactivated	
Chlorine dioxide	Bacteria	Ct_{99}: 0.13 mg·min/litre at 1–2 °C, pH 7; 0.19 mg·min/litre at 1–2 °C, pH 8.5	
	Viruses	Ct_{99}: 8.4 mg·min/litre at 1 °C; 2.8 mg·min/litre at 15 °C; both at pH 6–9	
	Protozoa	*Giardia* Ct_{99}: 42 mg·min/litre at 1 °C; 15 mg·min/litre at 10 °C; 7.3 mg·min/litre at 25 °C; all at pH 6–9 *Cryptosporidium* Ct_{99}: 40 mg·min/litre at 22 °C, pH 8	

Treatment process	Enteric pathogen group	Baseline removal	Maximum removal possible
Ozone	Bacteria	Ct_{99}: 0.02 mg·min/litre at 5 °C, pH 6–7	
	Viruses	Ct_{99}: 0.9 mg·min/litre at 1 °C, 0.3 mg·min/litre at 15 °C	
	Protozoa	*Giardia* Ct_{99}: 1.9 mg·min/litre at 1 °C; 0.63 mg·min/litre at 15 °C, pH 6–9 *Cryptosporidium* Ct_{99}: 40 mg·min/litre at 1 °C; 4.4 mg·min/litre at 22 °C	
UV irradiation	Bacteria	99% inactivation: 7 mJ/cm^2	
	Viruses	99% inactivation: 59 mJ/cm^2	
	Protozoa	*Giardia* 99% inactivation: 5 mJ/cm^2 *Cryptosporidium* 99.9% inactivation: 10 mJ/cm^2	

Note: Ct and UV apply to microorganisms in suspension, not embedded in particles or in biofilm.

Source: WHO Guideline for drinking water Quality, Third Edition 2004.

Annexure-XII

Nodal / Referral Laboratories

Chemical

Central Pollution Control Boards (CPCBs),

Defence Research and Development Establishment (DRDE), Gwalior

Indian Institute of Chemical Technology (IICT), Hyderabad

Industrial Toxicology Research Centre (ITRC), Lucknow

National Environmental Engineering Research Institute (NEERI), Nagpur;

National Chemical Laboratory (NCL), Pune

National Institute of Occupational Safety and Health (NIOSH), Ahmedabad,

National Poisons Information Centre (NPIC), AIIMS, New Delhi

Petroleum and Explosive Safety Organisation (PESO), Nagpur

Biological

Central Research Institute (CRI), Kasauli (HP)

Defence Research & Development Establishment (DRDE), Gwalior

National Institute of Communicable Diseases (NICD), Delhi

National Institute of Virology (NIV), Pune

Indian Veterinary Research Institute, Mukteshwar

High security Animal Diseases Laboratory (HSADL), Bhopal

Regional Medical Research Centre (RMRC), Dibrugarh (Assam)

King Institute of Preventive Medicine (KIPM), Chennai, Tamil Nadu,

Haffkine Institute, Mumbai;

Radiological /Nuclear

Bhaba Atomic Research Centre (BARC), Mumbai

Defence Research & Development Establishment (DRDE), Gwalior

Department of Atomic Energy (DAE), Mumbai

Institute of Nuclear Medicine and allied Sciences, New Delhi

Inter-University Accelerator Centre, New Delhi

Nuclear Power Corporation, Mumbai

National Physical Research Laboratory (NPCL), Ahmedabad

Radiation Biology and Health Science Division, BARC, Mumbai

Faculty of NBC Protection, College of Military Engineering, Pune

Annexure-XIII

Important Websites

Ministry/ Institute/ Agency	Website
Council of Scientific and Industrial Research	http://www.csir.res.in
Defence Research Development Organisation	http://www.drdo.org
Department of Atomic Energy	http://www.dae.gov.in
Disaster Management Institute, Bhopal	http://www.dmibpl.org
Indian Institute of Chemical Technology	http://www.iictindia.org
Industrial Toxicology Research Centre, Lucknow	http://www.itrcindia.org
Ministry of Chemicals and Fertilizers	http://chemicals.nic.in
Ministry of Commerce and Industry	http://commerce.nic.in
Ministry of Defence	http://mod.nic.in
Ministry of Environment and Forests	http://www.envfor.nic.in
Ministry of Health and Family Welfare	http://mohfw.nic.in
Ministry of Home Affairs	http://mha.nic.in
Ministry of Petroleum and Natural Gas	http://petroleum.nic.in
National Chemical Laboratory, Pune	http://www.ncl.res.in
National Civil Defence College	http://ncdcnagpur.nic.in
National Disaster Management Authority	http://www.ndma.gov.in
National Environmental Engineering Research Institute, Nagpur	http://neeri.res.in
National Institute of Virology	http://www.niv.co.in
National Safety Council, Mumbai	http://www.nsc.org.in
UNEP/DTIE	http://www.uneptie.org
United Nations Development Program	http://www.undp.org.in
World Environment Centre	http://www.wec.org

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NDMA, *'National Disaster Management Guidelines—Management of Nuclear and Radiological Emergencies'* ISBN: 978-81-906483-7-0, February 2009

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WHO, *'Guidelines for Drinking-water Quality'* Third Edition

Appendix-A

Participants of the meeting held on 17.05.2010

Sl. No.	Name	Designation
1.	Sh. R. S. Tyagi	Dir(SDM), DJB
2.	Sh. Ajeet Shekhawat	IG (Retd), CISF
3.	Sh. Ram Kishan	Centre Water Authority (C)
4.	Sh. Pitam Singh	AEWA
5.	Sh. R. C. Bahukhandi	ACWA
6.	Sh. Heejin Yang	Korbi, Korea
7.	Manisir Hyan	Korbi, Korea
8.	Abhishek Toshniwar	Toshniwal Insts MFG
9.	Dr. D. N. Sharma	BARC
10.	Bhagwat Ram	CWA
11.	B. Shekhawat	A/Chemist
12.	Torah Singh	Dy. Dir , CWA
13.	V. B. Saxena	-do-
14.	Dr.Amarjeet Kaur	Director ODMS
15.	D. R. Arya	Dir (T&QC)
16.	Col. A. K. Sahni, Sr. Advisor & Head	Army Hospital- R&R
17.	V.K. Rai	CSO
18.	A. K. Sharma	Asstt CMO
19.	Suresh Chand	Asstt. Chemist
20.	P. C. Sharma	Chemist
21.	JR Arya	Chemist, Nangloi
22.	Mahendra Prasad	Bactriologist
23.	Dr. Anil K Mishra	Asstt. Bactriologist

24.	R. L. Tomar	Bactriologist
25.	Mahesh Chand	ACWA
26.	Sandeep Verma	L/Tech
27	Dr. Beer Singh,	Scientist G, DRDO
28.	Ramesh Kr. Gupta	Asstt. Bactriologist
29.	M.K. Rai	Chemist
30	Dr. M. C. Abani	Sr. Specialist, NDMA
31.	Anuradha Bhagat	Scientist B, DRDO
32.	Dr. I.M. Umlong	Scientist B DRDO
33.	Dr. M. Boopathi	Scientist-D DRDO
34.	Lt Gen (Dr) D. Raghunath	SDTata Sorabji Cemtre for Research in Tropical Diseases
35.	Dr. Maninder Singh	JDLS, DRDO Hqs
36.	Dr.R. B. Srivastava	DLS Scientist G
37.	Maj Gen J. K. Bansal	Sr. Specialist,NDMA
38.	Dr. Ashok K.Singh	OSD to Secy DJB
39.	Sharad Kumar	Assistt. Chief Water
40.	Dr. R. Vijayaraghavan	Dir DRDE, DRDO
41.	Vinod Kumar	Chemist
42.	Dr. T. S. Sachdeva	Sr. Specialist, NDMA
43.	Dr.A. K. Sinha	SSB

******

Appendix-B

Core Group

1. Lt. Gen (Dr) JR Bhardwaj — Chairman
PVSM, AVSM, VSM, PHS
Member, NDMA

2. Dr. A. K. Sinha
Coordinator
Veterinary Officer
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3. Lt Gen (Dr)D Raghunath, PVSM, AVSM (Retd) — Member
Principal Executive
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4. Maj Gen (Dr) JK Bansal(Retd) — Member
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5. Col. A. K. Sahni — Member
Senior Advisor and
Head, Microbiology
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Army Hospital (R&R), Delhi Cantt.

6. Dr. R. Vijayaraghavan — Member
Scientist H
Director
Defence R&D Establishment
Gwalior

7. Dr. Beer Singh — Member
Scientist ‚G‘
Defence R&D Establishment
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8. Dr. T. S. Sachdeva — Member
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9.	Dr. D. N. Sharma Head Radiation Safety Sys. Divison Bhaba Atomic Research Centre Mumbai	Member
10.	Dr. M. C. Abani Sr. Specialist (Nuclear) NDMA Bhawan A-1, Safdarjung Enclave New Delhi-110029	Member

*****

Contact Us

For more information on this action plan please contact:

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