DISASTER PREPAREDNESS AND MITIGATION GUIDELINES

WASREB
Water Services Regulatory Board

WATER SERVICES FOR ALL KENYANS

FINAL REPORT

Consultancy services for preparation of guidelines on minimum requirements for disaster preparedness and mitigation measures for water utilities in Kenya.

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Acronyms

CEO	Chief Executive Officer
ELDOWAS	Eldoret Water and Sewerage Company
EOC	Emergency Operation Centre
ERP	Emergency Response Plan
FAO	Food and Agricultural Organization
GIS	Geographic Information Systems
GoK	Government of Kenya
GW	Ground Water
HACCP	Hazard Analysis and Critical Control Point
IPCC	Intergovernmental Panel on Climate Change
JOC	Joint Operations Centre
KEMRI	Kenya Medical Research Institute
KFS	Kenya Forestry Services
KfW	German Development Bank
KWS	Kenya Wildlife Services
KWSTF	Kenya Water Services Trust Fund
MDGs	Millennium Development Goals
MoU	Memorandum of Understanding
MSSP	Ministry of State for Special Programmes
MWI	Ministry of Water and Irrigation
NDOC	National Disaster Operations Centre
NEMA	National Environment Management Authority
NGO	Non-governmental Organization
PS	Principal Secretary
PVC	Polyvinyl chloride
RVA	Risk and Vulnerability Assessment
RWH	Rainwater Harvesting
SPA	Service Provision Agreement
TOR	Terms of Reference
US EPA	United States Environmental Protection Agency
UNICEF	United Nations Children Fund
VA	Vulnerability Assessment
WSPs	Water Service Providers
WASREB	Water Services Regulatory Board
WHO	World Health Organization
WSBs	Water Services Boards
WSS	Water Supply System
WWTP	Wastewater Treatment Plant

Contents

1.0 Preamble

Drinking water and, by extension, sewerage services are essential in ensuring the health and well-being of populations and as such fulfil an important role in the development process. They are, as would be expected, subject to disasters, both natural and man-made. In emergency or disaster situations these basic services are imperative for the rapid return to normalcy. The impact of a disaster can cause contamination of water, breaks in pipelines, damage to structures, water shortages, and collapse of the entire system. Depending on the level of preparedness that the water authorities have adopted, repair of the system can take days, weeks, and even months. It should, however, be remembered that drinking water utilities are held responsible for providing a safe and reliable supply of potable water to their customers with or without a disaster.

While little can be done to prevent natural hazardous events (e.g. earthquakes) steps can be taken to reduce and minimize the effects on water sector facilities by the development of appropriate preparedness and mitigation strategies and effective response planning. The best time to act is in the first phase of the disaster cycle, when preventive and mitigation measures can strengthen a system by reducing its vulnerability to hazards. The location of sources and the design of water-supply systems in general are critical in emergency and disaster preparedness. Hazardous events to catchments (e.g. forest fires or chemical contamination), reservoirs (e.g. drought, earthquake, contamination, landslides), pumping and treatment plants (e.g. flood, earthquake, fire, explosion, chlorine gas leaks), as well as to the distribution system (e.g. earthquake, flooding), need to be taken into account in citing, design and contingency planning.

The economic and public health implications of these disasters have provoked an urgent need for greatly improved management, planning, operation, and maintenance in the water supply and sanitation sector, associated environmental protection, and conservation of both surface and groundwater resources. The events of 9/11 helped accelerate the development of programs required to mitigate the vulnerabilities of drinking water utilities in developed countries and indeed the whole world.

The implementation of mitigation measures not only improves the capacity of emergency response, but also protects routine operations and makes the systems more reliable. For example, redundant or “back-up” measures designed for emergencies also safeguard routine operations. Likewise, strengthening routine corrective and preventive maintenance of installations favours effective response during emergencies.

In this guidelines report the term hazard means a source of potential harm or a situation with a potential of harm (e.g. a biological, chemical, physical or radiological agent or circumstances that has the potential to have a negative effect on the supply of safe and sufficient water). On the other hand, a hazardous event refers to an event that can cause harm (e.g. an incident or situation that can lead to the presence of a hazard, what can happen and how). Please note that the terms hazard and disaster are used interchangeably while the same case applies to hazardous event and disaster event.

2.0 Guidelines Development Methodology

In developing these guidelines, major inputs were in form of literature review, consultation with Water Services Boards (WSBs) and major Water Service Providers (WSPs), survey of utilities through site visits and use of a survey tool (questionnaire) and vulnerability assessments. All of these were key in hazard identification (and prioritization) from which relevant mitigation measures were drawn.

2.1 Survey tool

A survey of water utilities with Service Provision Agreements (SPA) from respective boards was conducted by means of a questionnaire. In addition to the questionnaire tool all the water service boards in the country together with major utilities under them were visited and chief officers interviewed. The boards and respective WSPs visited are as follows:

- Athi Water Services Board and Nairobi City Water and Sewerage Company
- Coast Water Services Board and Mombasa Water and Sanitation Company
- Rift Valley Water Services Board and Nakuru Water and Sanitation Company
- Lake Victoria South Water Services Board and Kisumu Water and Sewerage Company
- Lake Victoria North Water Services Board together with Kakamega Water and Sanitation Company and Eldoret Water and Sanitation Company
- Tana Water Services Board and Nyeri Water and Sewerage Company
- Tanathi Water Services Board and Kitui Water and Sanitation Company
- Northern Water Services Board and Garissa Water and Sanitation Company

The survey tool revealed a number of threats to water supply with potential to cause outages that can be disastrous in the country which include:

- Aging water supply systems
- Vandalism
- Negligible security in major installations – for example, the entire coast water supply has no security at all in all its sources
- Lack of alternative sources – for example, ELDOWAS has not developed any groundwater system
- Drought
- Floods
- Landslides - prevalent in Mt. Kenya region
- Poor quality of raw water- for example, Kisumu city
- Power bills – for example, utilities under TANATHI WSB have from time to time been rescued by MWI
- Other developments such as road construction works within corridors with service lines

2.2 Vulnerability Assessments

The wide range of risks that drinking water supplies are exposed to and the inherent vulnerabilities must be identified and analysed in order to identify and prioritise proper mitigation and preparedness measures. These assessments may be performed in different ways but they generally aim to provide relevant decision support that facilitate improvements of the supply system and make sure that the consumers are not exposed to unacceptable risks.

Climate change will exacerbate vulnerability and therefore increase risk level. **Climate change will affect the water balance, and particularly the amount of runoff and recharge, which in turn determines the water resources available for human and ecosystem uses.**

Climate variability and changes have been observed in Kenya like in the other parts of the world. The year-to-year climate variability in Kenya has been associated with anomalies in the circulation patterns of the wind and ocean currents that are commonly referred to as the general circulation. Too strong or too weak general circulations have been associated with floods and droughts worldwide including in Kenya.

Although sometimes hampered by lack of data, analysis of annual and seasonal rainfall trends over Kenya have indicated recurrences of below/above normal precipitation in association with anomalies in the large-scale patterns of the climate system. Another important indicator of climate change is the mountain glacier. It has been established that, the volume and extent of Mt. Kenya glaciers have shown a drastic declining trend. The mountain had as many as 18 glaciers at the turn of the century but only 11 have survived to the last decade with the overall area of less than 1 km^2.

Past studies on lake levels, lake shores and shoreline records have revealed a decline in Lake Nakuru (though in 2013 the lake had very high levels). Shorelines have also indicated that Lake Turkana could have been at a much higher level sometime ago. Lake Victoria reached its lowest levels in 1922. Lake Naivasha depicted a very sharp and sustained decline after 1938. The enhanced precipitation in 1960s significantly raised the majority of the Lake levels in Kenya. Lake Victoria rose by 1.5 to 2.2 m while *Baringo*, *Nakuru* and *Manyira* rose by about 2.3 m. Lake Turkana rose by about 4 m and submerged 300 km^2 of the *Omo* delta.

There are a number of serious environmental, social and economic consequences that could result from climate change, some of which could have far reaching impacts on the country. The third IPCC assessments that were circulated in 2001 noted among others that climate change would affect:

- **Natural ecosystems:** Climate change would affect adaptive capacity of natural ecosystems, including forests, range-lands, deserts, mountain regions, lakes, streams and wetlands, coastal systems and oceans;

- **Natural disasters:** Even without climate change, extreme climate events such as floods, drought, and tropical cyclones cause socio-economic havoc in many African countries. Changes in climate that result into changes on the mean, frequency, and / or intensity could be very devastating.

The vulnerability of a water resource system to climate change is a function of a number of physical features and social characteristics. The physical features associated with maximum vulnerability of water resources in a region include:

- The marginal hydrological and climatic regime;
- High rates of sedimentation leading to reduction of reservoir storage;
- Topography and land-use practices that promote soil erosion and flash flooding conditions;
- Deforestation, which allows increased surface runoff, increased soil erosion and more frequent significant flooding.

The social characteristics that increase vulnerability of water resources include:

- Poverty and low income levels that prevent long term planning,
- Lack of water control infrastructures,
- Inadequate maintenance and deterioration of existing infrastructure,
- Lack of human capital skills for system planning and management,
- Lack of appropriate and empowered institutions,
- Absence of appropriate land-use planning and management,
- High population densities and other factors that inhibit population mobility,
- Increasing demand for water because of rapid population growth, and Conservative attitudes toward risk, i.e. unwillingness to live with some risks as a trade-off against more goods and services.

Climate change can also trigger phenomena that can disrupt the operations of utilities. Phenomena associated with high precipitation such as landslides, floods etc may not directly reduce water availability but can impair operation of utilities. Overall, climate change is a major consideration when undertaking vulnerability analysis.

The desired outcome of vulnerability analysis is, logically, the application of prevention and mitigation measures to correct weaknesses revealed by the study. Mitigation measures are applied to the most vulnerable components, whether found in operational, administrative, or physical elements.

A Risk and Vulnerability Assessment (RVA) Tool was developed and tested in this case and was used to assess drinking water supplies and facilitate the identification and prioritisation of proper mitigation and preparedness measures. The RVA Tool is described in detail in volume II of this work. The tool is based on a risk ranking approach and facilitates an integrated from-source-to tap approach and does not require expert knowledge on risk assessment. The output of the tool provides guidance on what are the most severe risks and this information can be used when planning work on both the operational and strategic level. The results of the RVA Tool aim to provide input to the prevention and mitigation phases but also facilitate the planning and preparation for response and recovery.

2.3 Hazard identification

To develop effective mitigation and preparedness measures, it is important to identify potential hazards. Based on results of field surveys and other tools, potential hazards that may affect a utility should be identified so that mitigation and preparedness measures required to "disaster proof" the utility are formulated.

For a proper identification of hazards, the boundaries and structure of the system have to be defined. Within this guideline report, the water supply system is defined as all physical and the organizational structures for the supply of drinking water that stretches out from the catchment area to the customer (from source to tap). Thus, the water supply system is regarded as a whole and the identification of hazards done from the raw water source to the consumer's tap.

The hazards identified in this guidelines report are general hazards of technical, geographical or human origin, having direct effect on the infrastructure for water supply. Other types of hazards, for example, of political or economical origin are not assessed specifically in this report. The scope of hazards identified focus on the primary process of water supply.

In these guidelines the water supply system is subdivided into 9 sub-systems, of which 8 are physical sub-systems representing the installations and one is a non-physical subsystem representing organizational aspects. The nine sub-systems are as follows (see Table 1):

1. Sources
2. Intakes
3. Transport (for all sources from intakes to treatment works)
4. Storage
5. Distribution systems
6. Treatment systems
7. Organization
8. Access to facilities
9. System control and monitoring

Table 1: Components of water supply system considered

Sub-system	Components
Sources	1. Rainfall 2. Surface 3. Groundwater 4. Seawater
Intakes	1. Artificial catchments (roof tops, runway surfaces) 2. Structures in rivers and streams (dams, diversions) 3. Spring captures 4. Shallow wells (mainly for individual use) 5. Boreholes 6. Galleries (both groundwater and river/stream) 7. Desalination
Transport	1. Transmission mains (gravity and pumping)
Storage	2. Large impoundments 3. Reservoir tanks (all sizes, shapes, materials, in-ground, elevated)
Distribution systems	1. Gravity 2. Pumped (power required) 3. Combination (gravity plus pumping) 4. Pipelines (all sizes, materials, pressure rating, in-ground, above-ground) 5. Control valves 6. Crossings (rivers, streams, etc)
Treatment systems	1. None 2. Chlorination only 3. Sedimentation 4. Full treatment
Organization	1. Institutional organization 2. Administration 3. Operation and Maintenance
Access to facilities	4. By foot 5. By road (all weather, four wheel drive, stream crossings)
System control and monitoring	1. Manual 2. Automatic 3. Semi-automatic

Depending on their origin, hazards can be of two types:

a) Those related to natural events, i.e., physical phenomena arising in nature;
b) Those caused by human activity.

This classification cannot be employed rigidly since we often find interactions between natural phenomena and human actions. For instance, a landslide may be caused by erosion as a result of deforestation by human failures in channelling runoff or wastewater, or by settlements in unstable areas.

Another way of classifying hazards is by the way they occur such as sudden onset, as in the case of earthquakes and gradual onset, as in the case of drought.

2.3.1 Natural hazardous events

In general, natural hazardous events can be categorized as geological and meteorological hazardous events.

Geological hazardous events

- Earthquakes
- Tsunamis
- Volcanic activity
- Landslides

Meteorological hazardous events

- Tropical cyclones
- Floods
- Droughts

In order to control or minimize natural hazards, it is essential to know the characteristics of common adverse natural phenomena and how they impact on our environment. The study and proper management of such hazards is also a prerequisite for developing operational, planning, training and simulation programs. This entails the following:

1. Becoming familiar with, analyzing, and assessing the presence of natural hazards and their effect on the equipment and infrastructure of the area under study, based on the vulnerability associated with such phenomena;
2. Estimating the potential impact of natural hazards on routine as well as longer-term development activities, and on the components of water supply and sewerage systems;
3. Devising and adopting measures to reduce vulnerability and mitigate the effects of hazards;
4. Programming emergency operations.

Hazard potential depends on the location of each country in relation to the hazard source, especially in regards to geological hazards. For example, high island countries located near the high energy interactions between the Pacific Plate and the Indo-Australian Plate have a higher potential for earthquakes, volcanoes and tsunamis than other countries. In this regard, the Kenyan coast, while far from these plates, is potentially at risk. Meteorological hazards are more "mobile" and may strike more randomly thus location is not a limiting factor.

Note that hazards may be linked to one another causing one or more to occur. For example, earthquakes may generate tsunamis, while tropical cyclones may trigger landslides and flooding.

If we add to natural hazards the increasing vulnerability caused by human activity such as industrialization, uncontrolled urbanization, the deterioration of the environment, and terrorist attacks we see a dramatic increase in frequency and effects of disasters.

Results of risk and vulnerability assessments conducted for water supplies to the cities of Nairobi, Mombasa, Nakuru and Eldoret demonstrate and confirm that the country is at a higher risk to the following natural hazards:

(a) **Floods**

Flooding occurs as a result of excessive rain, abnormal increases in ocean level, massive snowmelts, or a combination of these phenomena. Precipitation is the result of a series of factors, including:

Latitude: In general, precipitation decreases with latitude since lower temperatures cause a decrease in atmospheric moisture.
Distance from the source of moisture: The closer a zone is to sources of moisture, such as oceans and lakes, the higher the probability of rainfall.
Presence of mountains: Ascending elevation generally favours precipitation. Rainfall is usually more intense on the sides of mountains exposed to the wind.

The magnitude of flood damage is related to:

- The level that waters reach in the flood, the violence and speed of currents, and the geographic area covered;
- The quality of design and construction of the works, and whether or not precautions have been taken for a certain level of flooding;
- The ability of the ground where installations are located to resist erosion, cave-ins, or landslides brought on by persistent or torrential rain.

The most serious consequence of flooding is large-scale contamination of drinking water. In such situations, water-borne illnesses usually associated with poor hygiene and sanitation can affect a large part of the population. Such illnesses include typhoid and cholera, where they are endemic, as well as dysentery, infectious hepatitis, and gastroenteritis. Because of the serious risk of appearance of these illnesses, methods of water treatment with chemical sterilization (such as chlorine) or boiling water for human consumption are of primary importance.

Physical damage caused by floods includes:

(i) Damage to pipelines and appurtenances (such as different types of chambers and valves):

- Soil erosion leading to sections of pipe being uncovered, displaced, or washed away;
- As ground water levels rise, pipes and chambers can be displaced and float, causing ruptures in the installations;
- Displacement and total loss of sections of pipe.

(ii) Damage to partially buried tanks - these tanks are usually located in high terrain and flood damage is rare. However, the following has been observed:

- Erosion of foundations, causing cracks and/or partial cave-in of tanks, especially when constructed of masonry rather than reinforced concrete;
- If a large part of the tank is underground, flooding combined with high ground water levels (likely in terrain where there has been prolonged rainfall) can cause the tank to float. The risk is greater if the tank is not full of water.

(iii) Damage to pumping equipment and electrical installations - this may occur in the following cases:

- If the flood level is sufficient, it can wet electrical engines, pumps, starters, or switchboards;
- Voltage lines can fall owing to erosion at the base of the poles causing damage to lines, switchboards, and substations.

(iv) Damage to intakes, dams, and other surface construction. If the dynamic forces of the flood are strong enough they can cause erosion around any of the installations. These conditions have an impact on water intakes and corresponding structures such as channels and water conduits, engine houses, treatment plants, etc.

(v) Damage to dams and reservoirs. Dams and reservoirs located in river channels are at high risk of flooding. Dams designed for drinking water supply are vulnerable particularly if there is limited overtopping capacity. If the spillway and waste gates are inadequate, there is a risk that the dam could collapse, causing yet another disaster and enormous additional losses as a result of the avalanche of stored water.

In summary, the main impacts of floods on drinking water systems are as follows:

- Total or partial destruction of intakes located in rivers or ravines;
- Sedimentation resulting in silting up of components;
- Loss of intakes because of changes in the course of rivers;

- Breaks where exposed pipe crosses ravines and/or rivers;
- Breaks in distribution pipelines and connections in coastal areas as a result of wave action, and in areas adjacent to water channels;
- Contamination of the watershed;
- Damage to pumping equipment;
- Indirect impacts such as the interruption of electricity and communications, and road blockages;
- Intrusion of salt water into continental aquifers, contaminating or reducing the availability of groundwater.

(b) **Droughts**

Droughts, unlike other natural disasters, do not occur suddenly, but are slow-onset disasters resulting from insufficient rain (or snow) over a period of months, and sometimes, years. Its effects are principally seen in the decrease or extinction of sources of drinking water. Surface water such as rivers and ponds will usually suffer the effects of drought before ground water, owing to two main factors:

- Surface water generally flows much faster than water filtered through soils, and will reach the sea faster. River volume is quickly affected by drought (or heavy rain) unless there are lakes or artificial reservoirs to regulate annual variations in precipitation and the flow of a corresponding river.
- Ground water has two characteristics that are very effective in minimizing and delaying the effect of the drought (especially if hydro-geologic conditions are favourable). First, the pervious soil provides large water storage capacity, and second, runoff is slow. This speed, which is on the order of a few meters per day, implies that the flow is the result of rain infiltration over many years and fluctuations are less dependent on annual changes in levels of precipitation.

Damages caused by droughts are as follows:

(i) Damage in Surface Sources of Drinking Water

Depending on the characteristics of surface water sources and the type of drought, impacts could include a decrease in the normal volume of drinking water, which, depending on its severity, could result in moderate to severe rationing or the total extinction of some sources.

(ii) Contamination

Droughts can also lead to a contamination of sources of drinking water due to:

- Decrease in the self-cleansing capacity of rivers or ponds because of reduced flow;
- Increased concentration of pesticides, insecticides, or industrial wastes;
- Decreases in free oxygen resulting in contamination from fish kill-off;
- Contamination caused by dead animals near intakes for drinking water.

Depending on the duration of the drought and local hydrogeological characteristics, there can be new demands on ground water for emergency drinking water supplies and for industrial and agricultural use. The resulting decrease in the water table will reduce the productivity of wells and require increased pumping to obtain the required flow. This may entail an increase in operation costs for wells and a decrease in the productivity of pumps.

To supplement or replace surface water sources it may be necessary to:

- Construct and equip emergency wells to supplement drinking water supply;
- Take over wells used for other purposes (industry, recreation, or agriculture) to provide the public with drinking water.

In summary, the main effects of droughts on drinking water systems include:

- Loss or reduction of surface and groundwater sources, and deterioration of water quality;
- A decline in water levels at intake points and in storage facilities;
- Rationing and suspension of service;
- Reliance on water from tank trucks, with the consequent loss of water quality and increase in costs;
- Accumulation of solid matter in sewage systems;
- Damage to the system due to lack of use;
- Abandonment of the system.

(c) **Landslides**

Landslides are the result of sudden or gradual changes in the composition, structure, hydrology or vegetation of sloping terrain. They are often closely linked to primary hazards such as earthquakes or water saturation caused by intense rainfall. In urban areas they are also associated with human actions such as providing drinking water services to communities located on slopes with unstable soil. Leaks in these systems lead to excessive moisture in the soil and can result in landslides. The situation can be critical when drinking water is supplied without providing proper sewerage at the same time.

The magnitude of the impact of landslides depends on the volume of the mass in motion and its speed, as well as the extension of the unstable zone and the disintegration of the mass in motion. Landslides can often be predicted since they can be preceded by cracks and undulations in the terrain.

The expected impacts of landslides on drinking water system components include:

- Total or partial destruction of all installations, in particular intake and distribution structures located on or in the main path of active slides, especially in unstable mountainous zones with steep slopes or in slopes with steep grades that are susceptible to slides;

- Changes in the physical or chemical characteristics of intake water, which will affect treatment;
- Contamination of water in surface intakes in mountainous areas;
- Indirect impacts such as the interruption of electrical service, communication or blockage of roads.

(d) **Earthquakes**

While earthquakes are not prevalent in Kenya, they are one of the most serious hazardous events, given their enormous destructive potential, the extension of the areas affected, and the impossibility of forecasting their occurrence. Dislocations in the earth's crust, the main cause of earthquakes, deform the rocks below the earth's surface and build up energy that is suddenly released in the form of seismic waves that shake the surface.

An earthquake has a specific magnitude, but its intensity varies depending on the location of the area under study with respect to the epicentre, the geological characteristics of a site, as well as materials used for structures. The significance and type of damage relate to the magnitude of the earthquake and the area covered, the degree to which buildings and infrastructure are seismic resistant, and the quality of soil where structures are located.

Following are some of the types of damage that an earthquake can inflict on water supply and sewerage systems:

- Total or partial destruction of intake, transmission, treatment, storage, and distribution systems;
- Rupture of transmission and distribution pipes and damage to joints between pipes or tanks, with consequent loss of water;
- Interruption of electric power, communications, and access routes;
- Deterioration of the water quality at the source due to landslides and other phenomena;
- Reduction in yields from groundwater sources and flow in surface water sources;
- Changes in the exit point of groundwater or in the phreatic level;
- In coastal areas, inland flood damage due to the impact of tsunamis;
- Introduction of salt water into coastal aquifers.

2.3.2 Man-made Hazards (Technological)

Man-made hazards are becoming more frequent, especially with regards to waste disposal and pollution that threatens already limited natural resources such as freshwater. Technological hazards, usually caused by human activities can include the following:

  - Power loss
  - Fire
  - Chemical spillages from mining and other activities
  - Pollution of water resources
  - Accidents

- Acts of war, conflicts and terrorism
- Vandalism
- Systems Failures

Disasters in the operations of the water utilities may also occur due to neglect and/or failure of the organization to properly institute and adhere to maintenance procedures. Natural hazards can produce technological hazards by earthquakes causing electrical and gas fires as well as petroleum and chemical spills.

Fortunately, there have been no documented terrorist attacks on water supply facilities in the magnitude that will affect the services as yet. However, water supply systems have certain characteristics that make them vulnerable to terrorist attacks: the system covers a large area that may not be monitored by the authorities at all times and; the systems have components that are vulnerable to sabotage, for example, isolated reservoirs and pumping stations.

The vulnerability assessment has ranked vandalism highly as a major and prevalent man-made disaster that drinking water systems are facing. This has been found to be fuelled by the proliferation of scrap metal dealership in the country.

Future hazards

The following categories of future hazards have been identified:

- New chemicals and changed chemical pathways
- Emerging pathogens
- Climate changes
- Aging distribution systems - though this is a reality even in the present.

3.0 Disaster preparedness and mitigation measures

History reveals that greater attention has been paid to rehabilitation and reconstruction efforts than to making them unnecessary in the first place. This approach should be changed by setting in motion emergency and disaster reduction measures. These must focus on the preventive maintenance of structures and equipment, as well as the establishment and updating of those operational procedures and manuals that help to integrate the accumulated expertise of the staff.

Disaster preparedness minimizes the adverse effects of a hazard through effective precautionary actions, rehabilitation and recovery to ensure the timely, appropriate and effective organization and delivery of relief and assistance following a disaster. Long-term risk reduction measures are intended to minimize the adverse effects of a hazard by eliminating the vulnerabilities, which hazards would otherwise expose. These measures directly reduce the potential impact of a hazard before it strikes. Disaster preparedness assumes that certain groups of people or property will nevertheless remain vulnerable, and that preparedness will have to address the consequences of a disaster's impact. Disaster mitigation includes both disaster preparedness and prevention.

The execution of a prevention program in companies responsible for water supply and sewerage systems will be effective if the following issues are borne in mind:

- The timely application of preventive measures based on the most likely and severe potential disasters and the availability of appropriate information in the short term;
- Integration of measures in a single program containing different levels or areas of execution based on existing resources;
- The identification of the key areas where the application of preventive measures is most needed and hence most urgent;
- Appropriate management of resources and their timely application;
- The introduction of preventive measures in the everyday activities of the agency or company.

The creation and promotion of a culture of prevention and mitigation in the workplace ensures that the adoption of measures to improve potentially vulnerable structures can be carried out in a planned, progressive fashion, both in times of calm and during states of alert.

After identification of the hazards that may affect a utility, the following sections briefly describe some of the mitigation and preparedness measures required to "disaster proof" the utility. A detailed matrix comprising of water supply system components, the hazards likely to affect each respective component, the hazardous events behind each hazard and the suggested mitigation measures subsequently follows.

3.1 Preparedness and mitigation measures for physical components

Measures involving physical actions and establishment of standards require the greatest financial investment. They include improvements to existing infrastructure, new construction, and the implementation of improved design and building codes, among others.

Sources

Sources may be affected by the lack of rain (droughts) or by too much rain (flooding). Associated with drought is the depletion of available water resources. This is especially critical with groundwater lenses and coastal aquifers (e.g. Lamu), where saltwater intrusion may occur due to a combination of reduced recharge and over abstraction. Groundwater lenses may also be affected by surface saltwater intrusion from prolonged sea sprays and coastal flooding (seawater) inundation caused by tropical cyclones and tsunamis. Careful monitoring of lens thickness and groundwater abstraction rates is required.

Water supply sources such as surface catchments (rivers and streams) and groundwater recharge areas (wells, galleries and springs) should be protected from land developments and other activities that may adversely affect both water quantity and quality. It is a well-known fact that clearing or developing catchment areas results in increased and more rapid runoff, lower river-base flows and poorer water quality. Also, the development of catchment and recharge areas normally results in greater potential for pollution and erosion. Ideally, legislation should be enacted to protect all existing and potential water source areas for sustainable water resources now and for future generations.

Tropical cyclones (uncommon in Kenya) are known for their heavy rainfall and high winds that can saturate, strip and erode catchments and cause landslides. River channels may be blocked or dammed by landslide debris caused by rain and/or earthquakes. After cyclones and earthquakes, water resource catchments should be inspected for any major changes. Eroded areas should be replanted or other appropriate soil conservation measures used to stop further erosion occurring.

Earthquakes may damage catchments such as rooftops, aircraft runways and rock catchments. Volcanic ash showers are known to deposit ash material on catchment surfaces and in open storage reservoirs. Artificial catchments are also subject to seawater spray (increased during cyclones) that may find its way into reservoirs thus contaminating stored freshwater.

The collection of rainwater from both individual homes and public buildings should be encouraged by utilities as a “drought proofing” measure. In most cases this would provide some relief for utilities with limited water resources.

Intakes

Structural damage to in-stream water supply intakes may be caused by flooding, earthquakes and volcanoes. Intake structures should be designed to standards that consider damage by extreme natural forces. Also, intake head-works may become blocked and filled with silt and debris due to flooding, landslides and erosion. Silt traps constructed upstream from water supply intakes are useful. Properly constructed infiltration galleries installed in stream or adjacent to alluvial streams may be unaffected by flooding and debris caused by natural disasters but still require maintenance to remove surplus deposits of silts and debris.

Ground movements following earthquakes may affect groundwater wells, boreholes and galleries causing them to collapse, damage pipe work and change alignment. Changes to water quantity and quality may result and these should be closely monitored.

Storage

Earthquakes may cause structural damage to storage facilities that may result in either failure or leakage. Dams and concrete structures should be checked as soon as possible to ensure their integrity. Large uncovered reservoirs are subject to contamination by salt spray and losses through high evaporation rates. Where possible, storage tanks should be covered to protect freshwater from contamination and evaporation.

It is good practice to monitor storage levels or volumes to account for changes. For example, a broken water main or damage to the reservoir may cause a sudden unexpected decrease. The ability to isolate a storage facility is also desirable during and/or after a natural disaster to save water that may be lost or wasted through damage to the reticulation system. Outlets from storage facilities should be closed after an event to save wastage of stored water through leaks and broken pipes. Once it is known that major distribution faults are under control then the storage facilities can be opened, resulting in minimization of water wastage.

However, if fire is a factor then a decision must be made on whether to provide reticulated water to assist fire fighting. Note that access to storage facilities should be controlled and restricted to authorized personnel thus avoiding possible man-made disasters. Construction of additional storage is an ideal method to assist in “drought proofing” a utility, assuming that there is enough water to fill the extra storage.

Distribution Systems

The extensive nature of distribution systems increases their risk to natural hazards such as earthquakes, floods, cyclones, landslides and volcanic activity. Pipeline failures and leakages are common results of natural hazards. Thus water is wasted and does not reach the areas where it is required. The same is true for wastewater pipelines where broken pipes may lead to environmental hazards such as pollution of freshwater resources (both surface and groundwater) and coastal marine waters.

Sandy soils suit pipe laying but make it very difficult to locate broken and leaking pipes buried in these highly permeable soils. The installation and monitoring of bulk water meters at various locations throughout water supply systems is an excellent way to assess areas of high water usage and their readings may relate to damaged pipelines.

Pipelines (often PVC) lying exposed make them vulnerable not only to natural hazards but manmade hazards as well. The use of an appropriate pipe material can minimize breakages. PVC pipes should always be buried while steel pipes are most suited for out-of-ground use.

Power failures may also disrupt both water and wastewater reticulation systems when pumps fail to operate. Where this may cause a major problem, standby emergency power supplies should be considered.

Often the refilling of water pipelines is a problem due to air getting trapped in high sections preventing the flow of water. Air valves installed at high locations along the pipeline will expel trapped air while refilling the system.

Periodic maintenance of all types of valves is important for the efficient operation of a water supply system.

Treatment Plants

Structural damage and operational failure may occur from natural disasters resulting in the build-up and overflow of untreated water. Stand-by emergency power supplies to ensure continuous operation may be appropriate in some facilities that may cause environmental and health problems if the power failed.

Water-treatment plants should be provided with by-pass facilities to enable untreated water to be supplied in case of prolonged treatment plant problems. In the aftermath of a disaster, untreated water is better than no water at all. In those circumstances water utilities can issue instructions to the public to boil water used for drinking and cooking.

Damage to chemicals stored at treatment plants or other locations is another potential problem especially chlorine in its many forms (gas, granular and liquid). Special storage procedures recommended by manufacturers should be followed.

Access and Communication to Facilities

During and after a disaster, knowing the degree of damage caused by the event to a water facility is most important in order to assess the situation and respond accordingly. Often intake, storage and distribution systems are located in remote areas with difficult access at the best of times. In most cases access requires a 4-wheel drive vehicle. A fleet of well-maintained and equipped vehicles is most important especially during emergencies. Vehicles should all be equipped with communication devices and equipment in order to respond to an emergency quickly and efficiently.

During flood conditions access is very limited. The installation of bulk flow meters at accessible locations or the use of portable ultrasound flow meters can give an indication if a pipeline is functioning properly or if there is a problem. This can save time by only checking facilities where problems exist. Radio telemetric monitoring devices for water levels, rainfall, pipe flows, power failures and other functions are desirable not only for emergency purposes but also for normal operation and for recording system performance. Again, time can be saved by only checking facilities where problems exist.

Road access to major facilities should be maintained to provide reasonable access during extreme conditions. This may include road drainage control using water tables and culverts plus suitable stream crossing drifts that may be constructed using gabion baskets and readily available material from the riverbeds.

Field information on actual conditions must be communicated to those responsible for making decisions and implementing actions. Both vehicles and communication devices must be 'emergency-ready' at all times including full fuel tanks, spare radios and battery charger plus other equipment (chainsaws, portable generators and pumps) in working order. Alternatively, mobile telephony can be used.

It must be assumes that functioning communications systems, such as telephones, mobiles and telexes, may not be available in times of a major disaster. Plan a warning system around this assumption. Consider what type of communications equipment will be needed and sustainable if power lines and receiving stations are destroyed. Provisions for access to alternative communication systems should be explored.

Spare Equipment and Material (Stockpiling)

A well-equipped store is a valuable asset at any time but especially in times of emergency. Equipment and materials should be on-hand to repair or replace damaged pipes, valves, fittings, pumps and other gear as required. It is important to keep an up-to-date and accurate inventory of all equipment and materials available. Stocks that may be required for a range of emergencies should be ordered as soon as possible or beforehand as a safeguard.

Always consider the types and amounts of materials needed, whether they can be stockpiled, and where. This is not an easy task. In Kenya, and in many other countries of the third world order, the very poverty that makes large segments of our society vulnerable to disasters means that stockpiling significant amounts of relief materials is a luxury. However, this should not be used as an excuse for unpreparedness because the repercussions are far greater than the investment.

3.2 Monitoring and Early Warning Systems

Monitoring

Monitoring of systems (water levels, flow rates, water pressures, water quality and rainfall) to assess potential changes to water quantity and quality are a valuable tool in disaster management and mitigation. This is especially true in drought conditions that develop gradually and can tend to catch water utilities off-guard. The first indication of a dry period is often an increase in demand (watering of grass and kitchen gardens) and a reduction in water resources (decreasing water levels in streams, rivers and aquifers) and of course below-normal rainfall. By monitoring these indicators, water utilities may warn consumers to reduce water usage and/or impose water restrictions and/or rationing, thus conserving water resources. Note that the enforcement of restrictions/rationing should be in place to ensure that they are observed.

Early Warning Systems

A water utility should make use of disaster information and warning centres as part of its disaster mitigation policy. Early warning systems are normally comprised of various elements. They can stem in part from information provided by the meteorological department, by the

Ministry of Health (for example, epidemic outbreaks), or by the Ministry of Agriculture (for example, aquaculture pollution). For effectiveness, an established system to ensure the coordination of all these different inputs is required.

A utility emergency committee can serve this purpose. This sort of committee has to have clear-cut guidelines, reporting formats and mechanisms as well as established reporting procedures. An added complication involves the combination of this information with grass-roots information, the "early warning" information obtained from those most directly threatened, which is highly relevant and often ignored. This should not be the case.

Ensuring that appropriate information systems are in readiness includes stimulating information exchange systems within each agency in the emergency environment, between organizations and between the organizations and the public. The most appropriate means of gathering and disseminating early warning information must be carefully assessed and well defined. It is imperative that early warning messages be understood by the people for whom they are issued.

Declaring states of alert

Alerts may be issued by the utility or by a governmental agency at the national or county level. A state of alert covers the period between the moment an alert is issued and the mobilization of resources begins, and the moment of impact. In these situations it is prudent to establish two or three levels of alert, depending on the proximity and likelihood of impact. It is also advisable for colours to be assigned to each level of alert. In order to prevent confusion with the states of alert issued by national emergency authorities, however, it may be better to employ other systems of classification as unique as possible. The following system is suggested in this guideline.

The declaration of the state of emergency requires that the members of the Utility Emergency Committee (detailed under organizational preparedness) meet immediately and activate all legal, administrative, logistical and operational measures stipulated in the various procedures and protocols agreed beforehand. The types of alerts are illustrated in Table 2.

Table 2: Types of Alerts

ALERT	DESCRIPTION	ACTIONS	RESPONSI-BILITY
GREEN	Inform	Inform utility/company Board of Directors, Regional Emergency Committees, Local Emergency Committees, other institutions and the media.	
YELLOW	Prepare for direct and indirect effects	All emergency committees are informed; Manage public information; Verify stockpiles; Contact suppliers; Activate the Emergency Operations centre; Mobilize personnel based on priorities; Establish communication points; Activate bulk distribution points	
RED	Deal with direct and indirect effects	Mobilize resources; Damage and needs assessment; Rehabilitation of key water supply infrastructure.	

3.3 Organizational preparedness

Bearing in mind that each company or agency must act within the constraints of its own resources, the following is a list of those organizational components that should be in place and the roles they play.

The Company or Agency Board of Directors - the highest decision-making body of the company or institution - must establish all policies and strategies concerning emergencies and disasters. Depending on the structure of the company or institution, the relevant body might be a Board of Directors or Executive Board. The intervention of the board (the decision-making entity with the greatest executive capacity) will be most effective and relevant to the extent that there is, under its direct supervision, a specific unit or office responsible for emergency and disaster management.

Attention must be paid to National disaster response plan developed by the former Ministry of State for Special Programmes, which has established emergency and disaster response policies to ensure that water supply and sewerage services remain available in a crisis. They should discharge the following duties with respect to disaster preparedness:

- Set the general company or agency policy regarding emergency situations;
- Approve the establishment of an Emergency and/or Disaster Operation Centre;
- Appoint the members of the Utility Emergency Committee;
- Approve the Emergency Plan and the protocols for declaring a state of alert or an emergency within the company;
- Declare a state of emergency for the company or agency;
- Ask relevant government authorities to declare a state of emergency regarding the water supply and sewerage system if justified by the situation;
- Give consent and support to actions taken before, during, and after an emergency.

Utility Emergency Committee

Each utility should install a Utility Emergency Committee. This is the functional organ in charge of planning, organizing and guiding the use of human, material and financial resources, and any mitigation, prevention, preparedness, response, rehabilitation or reconstruction activities regarding emergencies or disasters. It is a decision-making committee that should be directly accountable to the company's directorate or other relevant top-level body, and will assume maximum authority in emergency and disaster situations.

The Committee should comprise, whenever possible, the company's highest-level decision-makers, including those in charge of the operational, administrative and financial divisions and other units relevant to emergency and disaster management. One option is to invite professionals from other institutions and sectors to be part of the Committee as a way of furthering inter-institutional and cross–sectoral coordination. The Committee should at the very least include representatives from the following areas:

- The general management office;
- The heads of the production, operations and maintenance divisions;
- The head of the administrative and financial division;
- The head of procurement (supplies and transportation);
- The heads of the development, works and engineering departments;
- The head of the planning department;
- The head of the company's public relations department;
- The official responsible for representing the company or agency in its interactions with civil defence bodies (in case he or she is not the same as the representative from the company's management office);
- The person in charge of the company's Emergency and Disaster Office or Unit.

The chair of the Committee should be occupied by the highest formal authority among the representatives appointed to the group. The relations of the Utility Emergency Committee with the national emergency committees, which normally includes representatives from several ministries, the police, and fire-fighters, are extremely important, particularly for coordinating the actions needed in a disaster situation. Accordingly, it is essential to make sure that a representative of the water supply and sewerage sector is a member of the national emergency committee as a liaison officer.

The chief role of the Utility Emergency Committee is to make the decisions needed to ensure that water supply and sewerage services can be restored in the shortest time possible after an adverse event. This calls for carrying out specific actions at each of the various stages in the disaster cycle.

Its members should meet periodically, at least twice a year or more frequently depending on their work–load, and obviously as often as needed during a state of alert or emergency. They should also discuss and approve the general guidelines for the disaster unit or group entrusted with designing or reviewing the emergency plan, including guidelines on mitigation, prevention, and preparedness if any.

The functions of the Utility Emergency Committee in broad terms include the following:

- Declaring a state of alert based on the relevant protocols established by the company's directors;
- Setting up the emergency and disaster office or unit;
- Monitoring the reviewing (or drafting) and implementation of the emergency plan;
- Coordinating the working program with the emergency and disaster unit;
- Monitoring the ongoing staff training on emergency procedures, which should include both theory and practice;
- Assigning priorities, coordinating, and overseeing the appropriate use of resources during an emergency;
- Forging and maintaining communications and coordination with the public institutions responsible for emergency and disaster management, both at the local and national level;
- Maintaining contact with private companies such as suppliers of equipment, chemical products and pipes, professional associations, and subcontractors;
- Coordinating emergency and disaster response efforts with the Emergency Operations Committees;
- Supporting the actions of the Emergency Operations Committees whenever there is a need for intervention at higher levels;
- Establishing the communication procedures, both within and outside of the company;
- Approving and securing the necessary financing for prevention and mitigation programs;
- Establishing and maintaining communication and coordinating activities with the public entities responsible for emergency response at the local or national level;
- Maintain contact with professional associations that can contribute to disaster and emergency response;
- Carrying out periodic review and updating of the emergency plan;

- Developing necessary budgets for implementing the plan and present them to the appropriate units;
- Declaring internal emergency alerts if an emergency has not been declared by national authorities;
- Providing and supervising ongoing training of personnel in emergency procedures.

The Emergency and Disaster Unit

It is the responsibility of the Emergency and Disaster office or unit to carry out, on an ongoing basis, the company's internal disaster prevention, mitigation and preparedness actions required by the Utility Emergency Committee, as well as to coordinate mitigation and response efforts with other institutions.

This office should have a formal and permanent place in the organizational chart, which evidently makes it possible to effect improvements in less time. When such a unit is not official, the functions described below must be assigned to the company's operational unit or other units selected for this purpose. Regardless of its internal status, this office is the executor of the guidelines provided by the Utility Emergency Committee.

The Emergency and Disaster Unit should comprise a coordinator who is assisted by professionals in operations, maintenance, planning, and engineering, as well as any others who may be needed. The office will work as a technical committee entrusted with specific goals, employing whatever existing technology may be required (such as geographic information systems or GIS). It should be provided with the necessary budget to outsource any specific studies that the company or agency cannot carry out on its own due to lack of specialized personnel. Such studies may include hydrogeology, structural, or soil assessments. This unit should also be able to requisition technicians and professionals on a part–time basis to engage in specific tasks such as the vulnerability analysis of a treatment plant. This would also require the collaboration of the head of the plant and other professionals.

Functions and Responsibilities:

The chief responsibility of the Emergency and Disaster unit must be the formulation, evaluation, control and monitoring of the Emergency and Disaster Prevention and Response Program. To fulfil this mission, the unit must procure vulnerability analyses of each of the components of the company's water supply and sewerage systems, follow up on the design of the operational plans, and carry out periodic evaluations to ensure that the plans remain up to date. In order to perform this work, it is essential for the unit to remain in direct and close contact with the Emergency Operations Committees.

The following are other main functions of the Emergency and Disaster Unit:

- Coordinate vulnerability analysis of the water supply and sewerage systems with the Emergency Operations Committee or Committees;
- Coordinate specialized vulnerability assessments with private or academic consultants;

- Assess the training needs of all staff regarding emergencies and disasters, including the type and level of training required by the various departments and employees;
- Promote, together with the company's training unit, the training required in the various relevant fields;
- Coordinate training activities with government agencies and universities;
- Review and periodically update the Emergency Plan;
- Ensure that all relevant information has been collected, including personnel and logistical data, plans and diagrams, descriptions of the systems, etc., required for vulnerability analyses and emergency plans;
- Oversee and assess the process for documenting emergencies so that the Emergency Plan remains up to date;
- Gather and document the lessons learned from various emergencies and disasters;
- Represent the company when dealing with civil defence or national emergency agencies.

Utility Emergency Operation Centre

In order to respond in a coordinated fashion to an emergency or disaster, there must be a physical space available that is secure and contains all the resources needed to function optimally during the most critical moments. Such a space is designated as Emergency Operation Centre (EOC).

A utility Emergency Operation Centre (EOC) reminiscent of the National Disaster Operation Centre (NDOC) and procedures ought to be established to receive system impact assessment information, develop strategies and to act accordingly. The centre will be the utility's focal point to respond to disasters, to communicate with national disaster offices, the public and other organizations required during the emergency. The location of the centre should be in a secure structure, able to withstand the severest conditions and be easily accessible. The Centre should be equipped with the necessary robust communication and emergency equipment to enable it to function uninterrupted, which may require stand-by power generators. At least one alternate site should be set aside for the centre in the event that the main is inoperable.

One option is for the Emergency Operation Centre to be located where the systems control centre is in normal situations, taking advantage of the telecommunications and control infrastructure if such is available.

It is important that the location of the Emergency Operation Centres be chosen strategically to allow for easy access and good communications. Above all, it is essential that the Emergency Operation Centre not be affected in any way by the adverse event. It could be located next to the company's communications centre and be permanently equipped with the following items:

- A list of telephone and fax numbers of the company's main officials as well as of key outside contacts;

- A connection to an electrical generator;
- Radio transmission equipment with the necessary communications protocols and power source;
- Radio and television receivers;
- Telephone and fax equipment;
- An Internet connection;
- Copies of the Emergency Plan and annexes;
- Technical specifications and plans of the system;
- Operations control panel or operational information system;
- Desks and meeting-room tables;
- Computer equipment and office equipment and supplies;
- Set of keys to all vehicles and infrastructure;
- Basic tools;
- General information, maps and plans of shelters, hospitals, health centres and other strategic facilities in the country.

The emergency operations centre should have the following characteristics:

- Minimal vulnerability to the most common hazards in the area
- Quick access routes
- Location within the drinking water and sewerage service area
- 24-hour security

Training

To be successful in minimizing harmful effects of emergencies and restoring normal operations requires training. It is crucial to provide training programs for water utilities staff, either in-house, or through outside sources. The purpose of training is to:

a) Educate staff about hazards and their impact on the system and,
b) Practice emergency response.

The emergency or disaster unit should be responsible for training in this area. One of the key points is to disseminate relevant information to all employees and produce, in cooperation with the company's general training unit/program, a structured training program involving different subjects and levels of detail to meet the needs of the various professionals and technicians who work for the utility. This training program must be carefully aligned with the objectives not only of the Utility Emergency Committee but also of the company or agency as a whole, so that it is not perceived as extraneous to the firm's core activities.

As part of developing in-house training or participating in other courses, the disaster unit should consider system size and complexity, probable emergencies, type of staff to undergo training, etc. Workshops should be designed for utility staff, either specifically or as an extra dimension of on-going programs. It is advisable to call upon members of professional groups such as civil defence agencies and universities to assist in training, particularly when it comes to specialized aspects.

A key component of the training must be emergency drills and simulations, which make it possible to assess the teamwork involved, especially decision making in high-pressure situations. Drills and simulations are generally carried out in the field and should cover the full range of potential scenarios, based on the existing hazards, so that the reactions by the staff, especially in terms of decision making, can be evaluated and serve as inputs to further refine the Emergency Plan.

These drills start with an emergency scenario and involve staff responding to the site that may be involved in that emergency. Internal and external communications may be tested. Suggested frequency of drills is annually. Drills are usually conducted locally, sponsored by city or town, fire or police department, and other affected organizations. Larger scale drills may be focused on one or more specific hazards.

Rehearsals/drills must be conducted system-wide and taken seriously. System wide means that all the components which would be involved in a real disaster situation should be rehearsed. Ensure that cynicism and half-heartedness does not minimize the impact of the rehearsal. Staff must persevere, because it is the nearest anyone will get, until disaster strikes, to seeing if the plan is effective. Rehearsals are also the only way to keep plans fresh, especially during extended periods without disasters.

Damage assessment and needs analysis

After a disaster has struck, damage assessment is of the greatest importance in obtaining a rapid diagnosis of the remaining functions and operational capacity of the systems, the damage suffered, its causes and required repairs, and rehabilitation. Such an assessment will obviously help to locate and quantify the needs that must be met in order to re-establish key services, and to estimate the time needed until they can be back in operation. While the services are being restored, other measures must be taken to distribute water essential for human consumption. Moreover, the resources needed to rehabilitate the affected components and the service must be estimated so they can be allocated as quickly as possible.

Damage assessment, in short, involves the identification and qualitative and quantitative examination of the effects of the event on the affected systems.

Two kinds of damage assessments should be performed after a disaster has struck:

Preliminary damage assessment - provides the most essential information no later than eight hours after the impact. This preliminary assessment is meant to gather the basic information needed by decision−makers to assign priorities based on the resources available in the region and to plan the actions that can restore water supply services to the largest number of users in the shortest time possible. If vulnerability analyses were completed prior to a disaster, the damage assessment can focus first of all on those components that were previously identified as representing the greatest risk for the system.

General Assessments - provides a more detailed account of the damage suffered by the systems, and it must be completed no later than 72 hours after the onset of the disaster. On the one hand, this assessment helps to make the necessary adjustments to the actions initially undertaken; on the other, it makes it possible to identify those needs that cannot be met by the company's own resources. Unlike the preliminary assessment, the general assessment is usually carried out by a team of specialists, which may include external consultants.

There is an additional type of assessment, known as the specific assessment, which is undertaken in those cases where the initial assessors have identified situations that must be evaluated by specialists. An example would be the need to carry out a structural analysis of a treatment plant or a dam.

Aid coordination

Establish a means to ensure a coordinated, useful and timely response from the international community if and when its assistance is required. Not only should such a mechanism incorporate inputs from bilateral donors, but possible assistance from non-governmental organizations should also be brought into the coordinating mechanism.

3.4 Financial Preparedness Guidance

Emergency response planning is the backbone of Disaster Preparedness for the Water Service Providers. The WSPs should have a documented Emergency Response Plan (ERP) complete with objectives of quick identification of emergencies, initiation of timely and effective responses, quick response and repair of damages to minimize service outages on both Technical and Financial aspects. Understanding vulnerability to disasters and planning for response is an important part of emergency planning, an efficient basic emergency disaster response plan should be the foundation of the response to all hazards that may be encountered.

The financial requirements of recovering from the disaster should drive the level of response required to mitigate the problem. The probability of an event or disaster occurring and its likely effect on the WSP's operations should be assessed. This can be done with the help of past disaster assessment as well as the RVA Tool. Focus should then be placed on the actions needed to reduce impacts and respond in a timely and effective manner.

To develop an effective financial emergency plan, a planning team approach should be utilized to establish roles and responsibilities prior to a disaster. For the financial ERP, the key departments would be the Finance and Commercial teams. However, there needs to be co-operation throughout the entire WSP. The other key parties to the general ERP will be:

engineering, operations, security, safety, planning, customer service, administration, finance, training and management.

Prior to formulating an efficient ERP, the WSP must familiarize itself with various elements of the disasters such as probability of the risk occurring, extent of financial expenditure that would be required to return to normal operations and important partners in the ERP process.

1. **Identification of risks:** The WSP should, with the help of the RVA Tool, list the various risks that it is prone to, as well as any disasters that are likely to occur in the area of the WSP. The probability of their occurrence should also be assessed. Potential disasters include floods, persistent droughts which lead to water shortages, pipe bursts, terrorist activities, wildlife destruction of infrastructure, landslides and so on.

2. **Estimation of financial loss upon occurrence of each disaster:** The WSP should, in addition to listing potential disasters, also include an estimate of the amount of financial loss that would accompany the disaster. This can be done by assessing what parts of the infrastructure would be affected, as well as revenue that may be lost from disrupted services. Each WSP may have varying estimates due to the infrastructure and equipment used at the water sources, treatment plants and so on. A sample list would be as summarized in Table 3.

3. **Setting aside internal funds as required:** The WSP should set up an Emergency Fund which can be topped up as required. The funds in the account should be commensurate to the probable level of damage that a disaster would cause. It can be built up through savings accounts, interest earning accounts (such as fixed deposit accounts, treasury bills or bonds and so on). Ideally, the Fund should not be drawn down except in the event of a disaster. It should also be accessible within short notice due to the unexpected nature of disasters.

Table 3: Sample list of Disasters

Disaster	Probability	Infrastructural damages	Financial Consequence	Estimated Recovery Funds required
Floods Droughts Terrorist Activities Pollution of water sources Intentional contamination Pipe bursts				

4. **Identification of crucial partnerships:** The ERP should involve crucial partners who would be of help in case of an emergency. Financial partners during disasters may include the World Bank, KWSTF, Foreign developmental finance institutions such as KfW, Ministry of Environment, Water and Natural Resources, local government (County Governments) and Water Service Boards. Other organizations that would be able to help in technical situations include: other WSPs, Kenya Red Cross, Kenya Police, KFS, KWS, Ministry of Special Programs and so on.

   Approach of the external funding sources should be dependent on the extent of financial assistance required. As such, depending on the extent of financing required, the WSP should begin from internal sources (savings, liquid investments and so on), then Water Service Boards, county governments, then the Ministry of Environment, Water and Natural Resources, and so on.

5. **Communication procedures:** Good communication is vital for effective emergency response. When a disaster occurs, panic and confusion may take over and poor communication can quickly make the situation worse. During water system emergencies there are several agencies that need to be notified and consulted. It is important for the WSP personnel to have a clear understanding of whom from the WSP would be responsible for what communication.

   Lines of authority must first of all be identified, which will clarify the responsible personnel and their authority in case of an emergency. A lead person should be identified that will have the responsibility and authority for managing the utility's response to an emergency (Emergency Response Manager). He / She can then set up a team who will spearhead the ERP. This will include leaders from various departments such as Commercial, Finance, Technical, Customer Service and Operations.

   Below is a sample table that could be used to identify the communication channels. This table may be modified by each WSP to fit their staffing requirements. Sample responsibilities are listed in Table 4. WSPs can further modify the responsibilities for their water system staff as needed.

6. **Emergency Response Trainings:** After putting together the ERP, a training program needs to be formulated that is both general for the entire WSP and also department-specific. This will ensure staff members of the WSP are clear on what is expected of them in case of any disaster. Each disaster should have its own procedure. This should then be approved by the board or the appropriate authority and used during each emergency situation.

Table 4 - Responsibilities and time frames for action

Name and Title	Responsibilities during an emergency	Time frame (days)
Finance Manager	Determine reimbursements from insurance and other sources. Determine how residual costs will be financed by the WSP. Release internal funds for disaster recovery. Apply for external funds as required. Execute agreements with suppliers for emergency equipment.	5+T 7+T 1+T 7+T 5+T
Technical Manager	Assessment of extent of immediate technical and other damage. Deploying personnel to begin emergency services and repair works. Complete detailed evaluations of affected facilities and infrastructure. Determine priorities for repair or reconstruction.	1+T 1+T 6+T 7+T
Commercial Manager	Assessment of revenue loss implications. Collection of data on the disaster for recovery efforts. Communication of the data with finance and technical team.	7+T 4+T 5+T
Communications Manager/ Public Relations Manager	Manages information flow to the general public and internally within the utility.	0+T

*T indicates the onset of the disaster

Financial Emergency Response Plan

The Financial ERP layout should ideally contain the following elements for each of the WSPs:

- **An Introduction:** Describing the objective of the ERP and its importance.
- **Emergency Planning Process**: The steps that were taken to ensure financial preparedness such as emergency fund preparation.
- **Integration and Operation:** The financial plan should fit in with the entire WSPs general ERP.
- **Communication Procedures:** Protocol in terms of roles during an emergency should be clear.
- **Restoration and Recovery:** The recovery process should begin as soon as possible. Finance department should also begin sourcing for required funds immediately.

- **Emergency Response Training:** This should include the procedure and timetable for training of the staff. Methods may include routine training drills, functional exercises, tabletop exercises and so on.

4.0 Preparedness and Mitigation Measures Matrix

The preparedness and mitigation measures are presented in a matrix contained in Appendix I. The matrix consists of five columns of which columns 2-4 are the key columns. The second column contains the water supply system (WSS) components that can be broadly grouped into physical and non-physical components. The third column identifies the hazards that are likely to affect each component while the fourth column shows the possible event or events behind the hazards identified. The fifth and final column contains the suggested preparedness and mitigation measures to address the hazards identified. It should be noted that a hazard can rarely be addressed by a single measure but often requires a combination of measures. For this reason, the guidelines have strived to give a wide range of preparedness and mitigation measures per hazard.

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Appendix I - Preparedness and Mitigation Measures Matrix

S/No	WSS Component		Hazards/Disasters	Hazardous/Disaster events	Preparedness &mitigation measures
1	**Source** i. Surface water ii. Groundwater iii. Seawater iv. Rainfall (RWH)	Surface water catchment	Contamination of catchment zone	Industrial discharge of chemicals and biological matter	Install coffer dams or tanks adjacent to the industry to prevent chemical discharges to the raw water; Locate the coffer dam or tank downstream between industry and raw water source and provide collecting ditches or channels; Ensure impervious ground surfaces; e.g. pavements or subsurface membrane layer; Treatment plant/additional units at the industry outlet.
				Sewer overflows due to rainfalls or failures	Rebuild combined sewers to separate sewers; Minimize the release of pathogens during wet weather flow, but do not treat the stormwater; Semi-natural devices such as infiltration trenches and ponds should be considered instead of large traditional storm sewers; Sustainable urban drainage systems (SUDS) include inlet control such as use of infiltration devices, vegetated surfaces, pervious pavements, filter trains and ponds.
				Effluent of WWTP (Waste Water Treatment Plant) from normal operations or failure	Treatment of discharges from sewer networks; Disinfection of treated wastewater, such as chlorination and ozonation; Enhanced treatment should be weighed against the likely formation of toxic by-products. The choice of disinfectant depends on the wastewater quality; Ecological friendly techniques exist, such as sunlight or artificial UV radiation to promote photochemical disinfection processes.
				Storm water effluents-Runoff from agriculture and urban green areas containing fertilizers, sludge, herbicides, etc; Disrupted inflow such as failure of dams and extreme runoff.	Encourage and undertake watershed restoration activities e.g. checked farming, afforestation, controlled anthropogenic activities etc; Exclusion of human settlement development in water catchment areas; Retention storage of stormwater; Reduce pollutants at their source in the society; Install additional treatment, such as wetlands before entering the recipient.

				Erosion into catchment with release of soil, sand or contaminants.	Eroded areas should be replanted or other appropriate soil conservation measures used to stop further erosion occurring.
				Earthquake/ landslides	Reinforcement of land areas with increased risk for landslides - Slopes with clay soil around surface waters need special considerations; Construct small retaining walls around the structures, or provide small anchors on the pipes; Change rigid components and place flexible piping in sinusoidal reaches; Bury pipes in solid rock in areas with steep slopes and little topsoil cover; Plant and maintain the vegetation coverage of the site or watershed; Remove vegetation from top and toe of very steep embankments; Provide structural retrofitting of the components; Retrofit or change cracked elements or those of poor quality material; Replace rigid connections and accessories.
				Deliberate contamination by sabotage or terrorist action;	Enhance security within major water towers.
				Salt intrusions from the sea	Avoid excessive drawdown of groundwater by controlling pumping and utilization of alternative sources.
			Siltation; soil erosion; uprooting of trees; loss of retention capacity; loss of vegetation;	Heavy winds; Heavy rains; landslides; earthquakes; human encroachment	Encourage and undertake watershed restoration activities e.g. checked farming, afforestation, controlled anthropogenic activities, etc; Exclusion of human settlement development in water catchment areas.
			Shortage of water	Drought	Ground water development; MoUs/agreements among utilities for mutual aid and interconnections where possible; Develop a robust water rationing program coupled with adequate training of consumers on water saving tips; Effect water demand management strategies; Have a source water protection plan and wellhead protection plan; Have access to an alternate raw water source, if situation allows; Model and reduce agricultural and irrigation water demand; Practice water conservation and demand management.

		Groundwater catchment	Contamination of Aquifers	Contamination by industrial operations; Contamination by wastewater (e.g. by WWTP); Leaching of contaminants by built constructions (e.g. landfills) using waste or contaminated ground, dumpsites; Construction activities with interference in subsoil (e.g. waterway construction, installations for handling or storage of hazardous substances, facilities for construction workers; etc., including accidents); Agricultural runoff and leach-out containing fertilizers, sludge, herbicides, etc.;	Maintain wells and surface water intakes; Apply setback distance to wellhead; Build infrastructure needed for aquifer storage and recovery; Diversify options for water supply and expand current sources; Install low-head dam for saltwater wedge and freshwater pool separation.
			Infiltration of GW by alien water (e.g. salt water intrusion, leaching of contaminated surface water...)	Wetlands and flood plains not hydraulically separated from the aquifer.	avoid over-abstraction
			Shortage of ground water resources	Ground water aquifer is not sufficiently fed or water is abstracted by others	Avoid over-abstraction; Engage in recharge activities such as development of injection wells, catchment conservation to curb runoff and enhance infiltration; Have a source water protection plan and wellhead protection plan.
		sea water	not prone to significant hazards		
		springs	water shortage;	drought; human settlement	Catchment conservation should be strictly observed
			contamination	human settlement	Avoid settlement close to spring sources

		RWH	contamination	use of contaminated receptacles; air pollution	Collect water in clean receptacles; avoid RWH from contaminated zones.
			Shortage / unavailability of water	lack of sufficient precipitation; insufficient catchment systems e.g. roof catchment	Encourage construction of RWH systems.
2	**Intakes** i. Artificial catchments (roof tops, runway surfaces) ii. Structures in rivers and streams (dams, diversions) iii. Spring captures	All types	Shortage / unavailability of water	Physical obstacles for the intake of raw water; blockage of water upstream of abstraction; siltation of intake sump	Silt traps constructed upstream from water supply intakes are useful; Maintain infiltration galleries and silt traps to remove surplus deposits of silt and debris.
				Failure of the raw water Intake; Water shortage or contamination leading to (partly) closing of intake, insufficient alternative raw water source	Possibilities to change raw water source during the failure; Reinforcement of land areas with increased risk for landslides; Intake structures should be designed to standards that consider damage by extreme natural forces; Maintain wells and surface water intakes; Apply setback distance to wellhead;
				Bad condition or external causes (e.g. landslides, earthquakes heavy traffic)	Changes to water quantity and quality may result in groundwater sources due to ground movements and these should be closely monitored; Intake structures should be designed to standards that consider damage by extreme natural forces.
				Algae blooms	Observe routine maintenance; Control use of fertilizers within the catchment area to check quantity of nutrients reaching the intake works.

	iv. Shallow wells (mainly for individual use) v. Boreholes vi. Galleries (both groundwater and river/stream) vii. Desalination			Drought	Refer to drought mitigation measures outlined above.
3	**Transmission** i. Gravity (clear/raw water mains) ii. Pumping(clear / raw water mains)	Gravity	Pipe/tunnel burst	Failure in mains or transport tunnels	Follow strict preventive maintenance program; always stockpile key repair materials; frequent monitoring of mains
				Bad condition of mains or external causes (e.g. landslides, heavy traffic)	replace old mains and appurtenances; re-route the vulnerable sections where possible
		pumping main / pumping stations	Power failure	Power interruption and no backup power supply	Install power supply back-up
4	**Treatment** i. None ii. Chlorination only iii. Sedimentation iv. Full treatment	General	Damage/destruction of treatment module	Natural disasters (e.g. earthquakes, storms); fires; poor construction conditions of the buildings; etc	Develop separate/ emergency pre-treatment systems e.g. plain sedimentation basins; Isolating the water plant from the distribution system through valves in case of contamination at the plant; Have access to alternative sources of treated water through adjacent systems (Memorandum of Understanding or Reciprocity Agreement with other water utilities); Reinforcement of land areas with increased risk for landslides.

		Raw water	Insufficient quantity of raw water	Hazards in raw water abstraction or transport such as those affecting sources, intakes and transmission systems	Ensure water abstraction and transport is enhanced from measures outlined for sources, intakes and transmission system
			Insufficient quality of raw water	Hazards in raw water abstraction or transport	Check quality related measures for sources, intake works and transmission outlined above
			Wrong sampling of the water	Contamination at sampling points (especially with negative pressures); sampling points not easily accessible.	Always follow a carefully designed sampling program conforming to a particular quality control standard; avoid relying on grab samples and always insist on representative samples
		Design	Inadequate design of the treatment process	E.g. ineffective removal of contaminants and control of DBP (Disinfected By-Products), lack of specific knowledge due to outsourcing, etc..	Retrofitting of the system should be considered
			Breakdown of systems	System layout (centralized or satellite)	Dispersed/distributed treatment works (satellite T/works) are preferable
		Operation	Non-optimal operation or maintenance of treatment process	E.g. not adequate coagulants or oxidants are used, improper pH value is maintained, no proper dose of coagulant or oxidants is used, lack of specific knowledge due to outsourcing, etc.	Proper operation procedures should be followed at all times; manuals and manufacturers' guidelines should be adhered to always
		Use of materials	Contamination or wear due to the use of materials not suitable for contact with drinking water	E.g. coatings, ion-exchange resins, iron not protected against corrosion, etc.	Always use approved materials for water supply purposes

		Electrical power	Power interruptions	No or unstable electrical power; no or failing back-up; automatic operation control switched off during storms and lightning; inability to pay power bills etc.	Having power back-up generators and diesel pumps at the water plant
		Maintenance of assets	Failure of the maintenance	Inappropriate maintenance scheme	Replace equipment or accessories if in poor condition, and monitor components periodically if they are in average condition (for example, electrical pumps, auxiliary generators, and valves); Repair elements, equipment, and accessories that are defective; Replace elements, equipment, and accessories that are inadequate or non-functioning; Obtain missing components, equipment, and accessories (for example, auxiliary generators in areas where there are prolonged or frequent electrical outages)

		Sedimenta-tion chambers	Inappropriate conditions during dispersion of flocculants or flocculation agents in the sedimentation basin; Inadequate floc settling; Improper design of setting tank; Improper operation or Inadequate desludging programme	Inappropriate pH, temperature and/or dispersing time of the dosing solution of flocculation agents, disturbing ingredients in the water the chemicals are dispersed with; precipitation due to stagnant regions in the water tank for flocculation agents build-up; etc; Wind and/or low temperatures; Retention time too short; mechanical failure of the stirrer; up flow velocity too high; weir overflow rate too high; insufficient sludge draw-off; retention time too short; reaction zone and/or clarification zone not sized correctly; wrong media specifications; poor bubble formation; etc.; Air release nozzles not kept clean or blockages not cleared; floc carry-over takes place	Proper design of these systems; proper operation of systems;

		Chemicals/ Disinfection	Bad quality of chemicals; Improper dosing of chemicals; Staff getting into Undesired contact with Chemicals; Chlorine gas leakages; Malfunctioning dosing systems	Problems at manufacturing and/or transport of chemicals; use of expired chemicals; Failure of dosing unit incl. power supply; no sufficient supply available; personal (operational) failure; incorrect measurement; Inadequate storage of Chemicals; Chlorination facilities do not comply with safety Regulations; Errors in chlorine solution concentration; blockages	Use of right quality chemicals; proper dosages; staff protective gear to be used at all times; Having spare parts, spare chlorine pump, etc.
		Screens	Blockages in screening sleeves	Incorrect screen size or inadequate cleaning; Floods, algal bloom or vandalism	Maintenance of screens; use of right size of screen openings and materials; security enhancement
		Coagulation / flocculation	High coagulant residual or reduced capacity; Insufficient Flocculation; Incorrect dosing of the flocculants or flocculant agents	Too low or too high coagulant dose; Improper coagulant mixing and/or flocculation; inappropriate flocculant or flocculation agent; improper pH control; Failure of the dosing pump; power failure in an automated controlled system	Proper determination of coagulant/flocculant doses at all times

		Filter beds	Filter damage; reduced filtration performance; filter blockage; shorter filter-run time	Deterioration; filter blockage; air underneath the filter bed; reduced cleaning performance. Inappropriate filtration speed, filter material, running time, layer thickness; insufficient elimination of flocs and/or flocculants; high hydraulic load or variations in flow through the filters during the filter cycle; high particle load in incoming water; wrong choice or inadequate depth of the media; wrong media specifications; etc. undesirable particles in the raw water; cleaning intervals too short or failure in the cleaning procedure; during installation insufficient flushing after the start-up operation of the filter; insufficient pre-treatment; shift in the particle-size distribution; etc. Changes in quality due to high turbidity in raw water or high dosage of Fe based coagulants.	Coagulation efficiency to be improved and maintained at all times; improve sedimentation performance; raw water sources should be maintained

5	**Storage** i. Large impoundments ii. Reservoir tanks (all sizes, shapes, materials, in-ground, elevated)	Service reservoirs & emergency storage i.e. warehousing	Loss of water	Earthquakes/earth movements causing structural damage;	Monitor storage levels or volumes to account for changes-(a broken water main or damage to the reservoir may cause a sudden unexpected decrease); Build storage tanks to resist common earth movements; Storage tanks should be covered to protect freshwater from contamination and evaporation
			Shortage of water	Sabotage/terrorist actions and other man-made disasters; Drought; "Damage or destruction of reservoir due to natural disasters (earthquakes, hurricanes, floods, landslides, volcanic eruptions)"; Damage or destruction of reservoir due to human caused accidents (car, truck or aircraft collision, landslides caused by reservoir leakage or nearby excavation); Intentional damage or destruction of reservoir (terrorism, sabotage, vandalism, arson); Reservoir structure damage due to excessive internal pressure build-up	The capacity to isolate a storage facility should be built; Access to storage facilities should be controlled and restricted to authorized personnel; Construction of additional storage is an ideal method to assist in "drought proofing" a utility, assuming that there is enough water to fill the extra storage; Extra treated water storage that can last a no. of days depending on Population; MoUs with packaging plants/companies

			Water quality deterioration	Intentional contamination of the network water (terrorism, sabotage, vandalism, arson); Poor hygiene during reservoir construction, repair or cleaning; Intrusion of contaminants through cracks in the reservoir roof, walls, floor etc; Aging of water due to low turnover rates or uneven hydraulic mixing; Excessive accumulation of sediments on the reservoir floor; Excessive biofilm accumulation on tank walls; floods events	Monitor maintenance & repair practices adequacy and safety by controlling potential contamination of reservoir water during repairs; Reservoir automatically insulated by shut-off valves designed to react in the event its destruction. System redundancy; Enhanced security by monitoring/controlling and eliminating unauthorized access to the site and ensuring access barriers; Enforcement of legislation on materials and compounds in contact with water for human consumption; Checking of the chemical/microbiological quality of the water before putting reservoirs in service; Proper design and maintenance of reservoirs provide a barrier to contaminants entrance; Implement best practice protocols for reservoir design (to prevent stagnant areas) and operation (to promote minimum required storage volumes).

6	**Distribution** i. Gravity ii. Pumped (power required) iii. Combination (gravity plus pumping) iv. Pipelines (all sizes, materials, pressure rating, in-ground, above-ground) v. Control valves vi. Crossings (rivers, streams, etc)	All systems	Deterioration of water quality	Insufficient network capacity due to inadequate design; Poor hygiene during pipes installation/repair; Intrusion of contaminated water due to low (negative) pressure in the network, in combination with cracks or leaking joints; Migrating substances from polymer material (e.g. vinyl chloride leaching from PVC pipes); Leaching of contaminants from cement made or lined pipes; Leaching of organic compounds from bituminous sealants and linings; Too long residence times of water in the network; Deficit in disinfectant residual, excess in water;	Checking of the microbiological quality of the installed/repaired zone water before putting pipes in service; Prevent waterborne transmissible-disease carriers to come into contact with the distribution system of potable water supplies; Using pipes made of materials and characteristics suited for the existing soil, and implementing a sound rehabilitation program; Implement operation and maintenance best practices which ensure minimization of negative pressures in the potable water pipelines; As much as is practicable lay major sewage pipelines below clear water pipelines to minimize ingress of sewage and possible cross-connections. Do not use or replace pipes of material that may release contaminants; Use of products complying with National Acceptance Scheme for products in contact with drinking water; Regularly flushing of dead-end and low flow pipes; Prevent and monitor possible excessive microbial re-growth; Water rich in sediments;

				Intentional contamination of the network water (terrorism, sabotage, vandalism, arson); "Re-suspension of sediments or sloughing of tubercle/biofilm due to rapid changes in water; Too high dosage of disinfectant residual (e.g., malfunctioning dosing pump(s).	Identify critical points allowing for intentional addition of contaminants to the systems water; Prevent access to the critical points. Establish conditions for fast implementation of measures to protect the consumers' health; Prevent and monitor possible excessive microbial re-growth; Implement operation and maintenance best practices;
			Distribution breakdown	Pipe burst due to extreme external-stresses (e.g. storms, earthquakes, landslides, freezing and thawing, traffic incidents, etc); Pipe burst due to increased external-stresses on pipe (e.g. traffic, soil movement, etc) in combination with a reduced pipe condition); Pipe burst due to bad condition of pipe (e.g. internal /external corrosion); Pipe burst/leakage due to increased internal-stress (e.g. pressure, transients); Loss of pipes' hydraulic capacity due to scaling/tubercle formation;	Redundant pipe connections & strategically placed valves in critical & vulnerable sections ; Preparing/updating distribution network mapping; Secure pipes at crossings & other precarious areas; Having spare parts available (valves, pipes, repair kits); Spare pipes & appurtenances; Maintaining networks by replacing old, damaged, and poorly built distribution system components; regular flushing, valve and hydrant exercising; Having redundancy by close-looping of networks and installing sufficient check valves, other control valves, etc.; Strategically position hydrants; Operational flexibility and alternative or backup supply; Rehabilitation of the affected network zones; Eliminate or minimize network hydraulic deficiencies.

		Bulk water Transportation i.e. Off-line water distribution (when not practical to use any part of the distribution network)	Significant breakdown of distribution system	earthquakes; landslides; floods	Flat-bed trailers with tractors; Forklifts; Fuel ; MoUs with neighbouring utilities; Agreement with bottling companies/packaging systems; Mobile treatment units; Strategic distribution points; Coordinate with other local emergency response programs; Properly locate and develop emergency distribution sites.

7	**Pumping**	pumping systems; pumping stations	No/low pressure/flow in network water;	Destruction of pumping station due to natural disasters (earthquakes, hurricanes, floods, landslides, volcanic eruptions); Damage or destruction of pumping station due to human-caused accidents (car, truck or aircraft collision, landslides caused by leakage or nearby excavation); Intentional damage or destruction of pumping station (terrorism, sabotage, vandalism, arson); Damage or destruction of network pipes due to water hammer, caused by absent or malfunctioning surge tanks; Pump malfunctioning/failure; Pump stoppage due to power failure/disruption and failing power back-up supply	Consider offline distribution; Pumping station location, design, structure and components based on locals disaster vulnerability assessments; Enhanced security by monitoring/controlling and eliminating unauthorized access to the site and ensuring access barriers. System redundancy; Prevent the development of destructive surge pressures by proper design, equipment and operation of the system; Availability of backup Pumps. Back-up power facilities automatically switched-on, the moment the utility power supply is interrupted; Protection of pump motor to lightning, loss of voltage or loss of phase. Redundancy of power supply; Minimize malfunction/failure events by implementing proper inspection and maintenance of pump and gauges functioning and condition. Replace equipment or accessories if in poor condition, and monitor components periodically if they are in average condition; Repair elements, equipment, and accessories that are defective; Replace elements, equipment, and accessories that are inadequate or non-functioning; Obtain missing components, equipment, and accessories
8	**Valves & other appurtenances (Isolation and control valves, Pressure reducing valves, etc.)**	All valve systems	No/low pressure/flow in network water.	Inadequate designed or operated valve; malfunctioning valve;	Periodic valve exercising followed by repair or replacement as needed. Provide that valves have adequate characteristics and functioning.

9	**Power supply systems**	All power systems	Power interruptions	Natural and man-made causes	Always have back-ups
10	**Communication systems & transportation**	All systems	Disturbance of communication in general	Natural and man-made causes	Improvements in communication systems, provision of adequate numbers and types of transport vehicles, provision of auxiliary generators, frequent line inspections; always stock alternative communication gadgets such as Portable radios with batteries and chargers; Tactical radio frequencies; Cellular phones with batteries and chargers
11	**Computer, control & monitoring systems**	All systems	Disturbance of the process in general & failure of monitoring system	Low quality of data input to information systems, incomplete, errors, etc; Operational fault in the automated processes due to inappropriate IT policy; Use of out-of-date or inappropriate software, that cannot be used by others; Accident, power failure, operational failure, sabotage, damaged monitoring devices	Monitor and inspect the integrity of existing infrastructure; Monitor current weather conditions; Obtain and use equipment such as Word processing computers, fax machines, phone lines, photocopy machines etc; Monitor flood events and drivers; Monitor surface water conditions e.g. Monitoring data for discharge, reservoir or stream level, upstream runoff, stream flow; Monitor vegetation changes in watersheds.
12	**Staffing**	All cadre	Ineffectiveness in operations and errors in operation	Inadequate and poorly trained staff	Always recruit and retain skilled staff at levels commensurate with needs; continuous training of staff in relevant fields; Training to assure staff safety during emergency (e.g. if water plant is flooded, electrical wiring may cause injury to personnel); Training on water plant operations to ensure that a backup operator is familiar with key components of the plant and water system

13	**Administration and operation**	Institutional organization	Disturbance of the process in general	Use of out-of-date guidelines; Inappropriate financial or technical conditions; Inappropriate personal organization (e.g. no assignment of responsibilities, no responsible person, inappropriate qualification); Insufficient on-call-duty; Insufficient and/or unqualified staff (e.g. certified, adequate labour); Insufficient internal coordination and scheduling; Operational fault in the automated processes due to programming by unqualified staff	Development of utility specific emergency preparedness and response program (Carry out vulnerability analysis, Develop mitigation plan, Develop emergency response plan); Within the program: - Create emergency response committee - Create emergency response centre
		Operation & maintenance	Disturbance of operations in general	Operational failures	Compile & document operation and maintenance programs; Obtain information on repair of any new & indeed all equipment from manufacturers; Develop lists of key personnel in the utility and from other institutions Provide specifications for all materials and accessories; Provide specifications for all equipment as well as the following items to be maintained at the local level (or agreements with owners); compressor, backhoe, electrical plant, sump pumps, equipment for clearing obstructions.

		Administra-tive support	Administration failures	Inadequate or lack of administrative support	Establish standards and regulations to ensure that financial resources are available for emergencies and that the procedures for accessing funds are flexible; Establish procedures to facilitate the transfer of personnel from areas not affected to disaster area; ensure procedures for contracting local personnel; Create mechanisms for transferring current lists of available stock, repair materials and equipment and vehicles to regional divisions; Develop through the procurement department, a list of private construction companies with available equipment.
14	**Security**		Loss of equipment and contamination threats	Vandalism, terrorism	Installing steel bars on windows and metal-reinforced doors; Not revealing exact location of intake works and other structures that cannot be protected by other means; Free access to water reservoirs should be limited or eliminated Installation of surveillance systems in key areas.
15	**Access to facilities** i. By foot ii. By road (all weather, four wheel drive, stream crossings)	All access systems	Inaccessible facilities	Natural disasters (floods, earthquakes, landslides)	Facilitate access to the water source by utility staff (access by boat, road); always maintain access roads and other infrastructure; procure and maintain at least one haulage tractor able to penetrate the worst imaginable terrain or condition

16	**Building safety**	All building areas	fire damage; water damage	fire; heavy rains	Avoid piles of loose paper in work areas; Unplug all non-essential machines at night and on weekends, including coffee pots; Store flammable materials in safe areas; Inspect work/office and storage areas twice a year for potential fire hazards; Regularly inspect fire extinguishers and other fire equipment; Train staff so everyone is familiar with procedures for fire and other emergencies; Conduct regular emergency drills; Enforce no smoking regulations; Turn off fans, heaters, etc. when the building is closed (unless they are rated for 24 hour operation); Store all books and other materials off the floor, even in upper stories; Check ceilings for leaks during heavy rain. Immediately remove materials from areas that have leaks. Use plastic sheeting to protect susceptible areas (stacks, storage areas, etc.) as a precautionary measure; Store boxes tightly against each other to minimize water penetration if materials are exposed to water; Update fire models and practice fire management plans; relocate facilities to higher elevation.