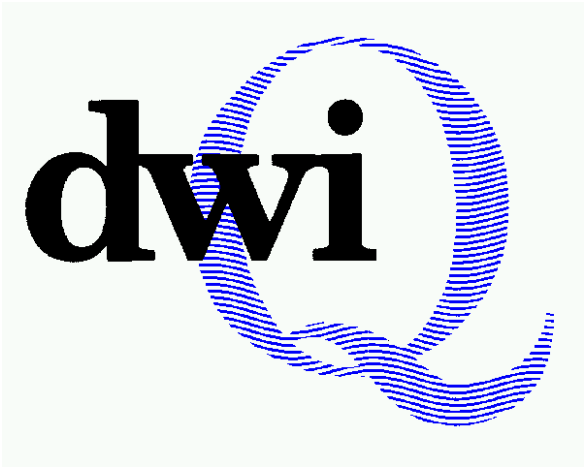


DRINKING WATER INSPECTORATE

guardians of drinking water quality

A Brief Guide to Drinking Water Safety Plans

Introduction

The Drinking Water Inspectorate strongly supports the World Health Organisation's initiative in promoting water safety plans as the most effective means of consistently ensuring the safety of a drinking water supply. This brief guidance is intended to give an outline of the process of constructing a water safety plan and a basic structure for what it should contain.

What is a Water Safety Plan?

A **Water Safety Plan** (WSP) is the most effective way of ensuring that a water supply is safe for human consumption and that it meets the health based standards and other regulatory requirements. It is based on a comprehensive **risk assessment** and **risk management** approach to all the steps in a **water supply chain** from **catchment** to **consumer**.

The primary objectives of a water safety plan in protecting human health and ensuring good water supply practice are the minimisation of contamination of source waters, the reduction or removal of contamination through appropriate treatment processes and the prevention of contamination in the distribution network and the domestic distribution system. These objectives are applicable to all water supply chains, irrespective of their size or complexity.

A WSP should ideally be developed for each water supply chain. For very small supplies this may be quite challenging and it would be acceptable to use a generic or model WSP for small water supply chains that are similar in nature with guidance on application to individual systems. Such generic or model WSPs could be based around a specified packaged technology. However, for all other water supply chains a WSP should be developed specifically for each system. Clearly WSPs can vary in complexity depending on the water supply chain.

Existing good water supply management practices form an integral part of WSPs, but they may not include **hazard identification** and risk assessment and management or be tailored for each specific water supply chain. A WSP is essentially a **framework** of hazard identification, risk assessment, risk management including the control measures, monitoring and incident and emergency plans and the associated documentation for each stage in the water supply chain. The water supplier is the key player in a WSP but other stakeholders have significant roles.

Essentially a WSP has three key components as follows:

- a **system assessment** to determine whether the water supply chain as a whole can deliver water of a quality that meets health-based targets. This system assessment identifies the potential hazards in each part of the water supply chain, the level of risk presented by each identified hazard and the appropriate measures to control the identified risks to ensure that the water supply is safe, the standards and targets are met and human health is protected;

- **operational monitoring** of an appropriate nature and frequency at an appropriate point in the water supply chain is defined for each control measure identified and implemented from the system assessment to ensure that any deviation from the required performance is rapidly detected; and

- **documentation of management arrangements** including details of the system assessment, operational monitoring and validation monitoring together with a description of the actions to be taken in normal operation and incident conditions when there is, or there is a risk of, non-compliance with a standard or target value or failure to meet an operational control, or there is a potential risk to human health. These actions should include appropriate investigations, remedial action in the form of improvement programmes, reporting and communication.

These three key components require:

- a thorough understanding of each element of the specific water supply chain and its capability to supply water that is safe and meets the health based standards, targets for indicator parameters and other requirements aimed at protecting human health;

- identification of the hazards for each element of the water supply chain, that is the potential sources of contamination and whether they present a risk for that element of the water supply chain and an estimate of the degree of risk;

- identification of the control measures for each identified risk and validation of those control measures;

- implementation of a system of routine monitoring of those control measures with criteria for triggering action when the control measures are not within the specified targets;

- implementation of a plan of remedial action when a control measure is not within the specified target with checking that the action has brought the system back under control;

- validation monitoring to determine whether the system is performing as assumed in the system assessment; and

- verification by an independent person or organisation that the WSP is being implemented correctly and is ensuring that the water supplied is safe and meets health based and other regulatory targets.

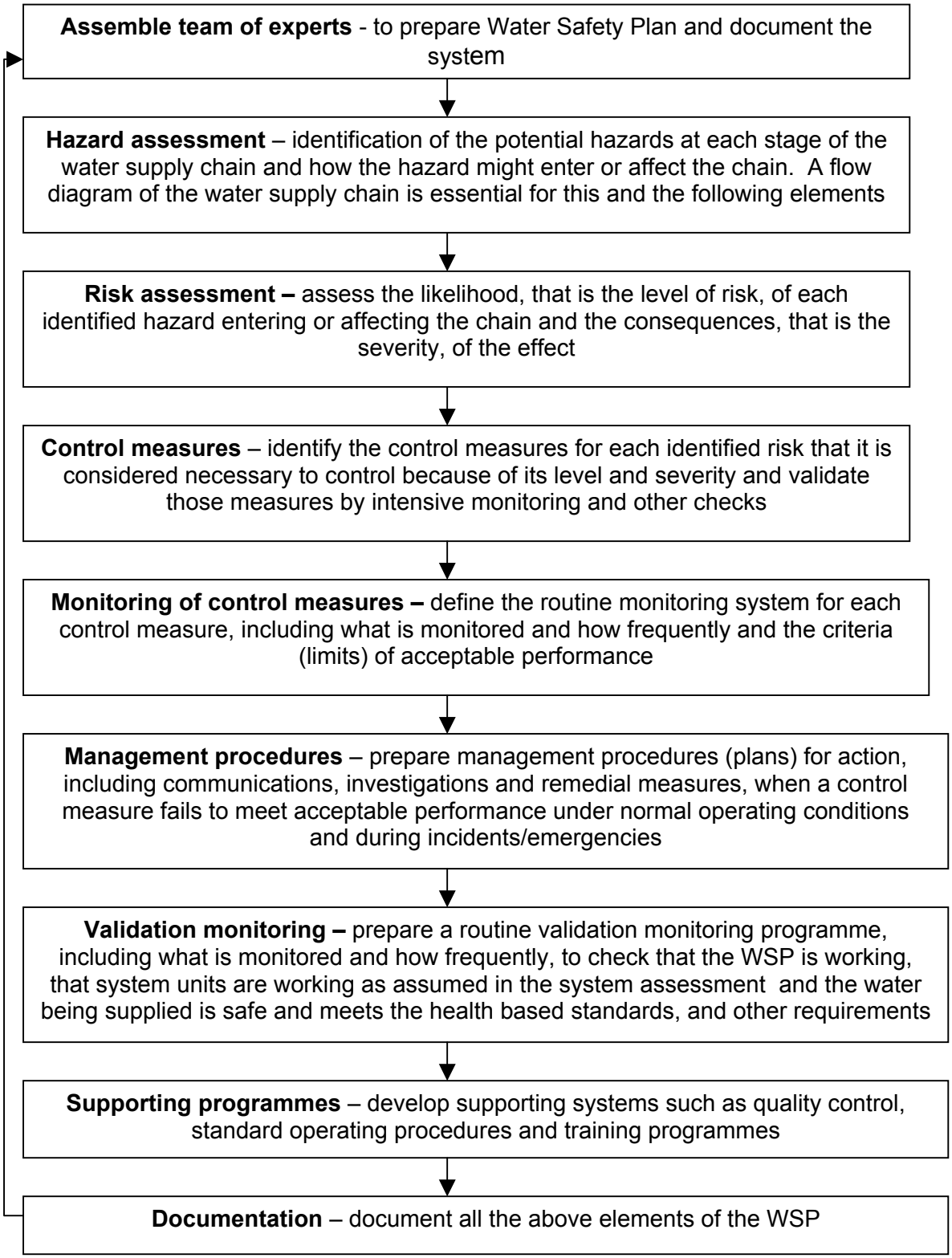
Guidance on the Preparation of Water Safety Plans

Assembling a team of experts

The first task for the preparation of a WSP or a group of WSPs is to assemble an appropriate team of experts with a thorough understanding of each stage of the water supply chains involved. This team should include specialists with knowledge of the catchment and raw water sources, water treatment processes, distribution networks, operations management, drinking water quality, public health and domestic distribution systems (consumer representative). Many of the team will be drawn from within the water supplier but others such as the catchment and public health specialists may be drawn from other organisations.

System assessment and design

The second task is to prepare a flow diagram that documents and describes the system to be used to prepare the WSP. Generally the flow diagram should contain the following elements:



The expert team, or designated individuals within the team, should carry out the steps in the flow diagram and document those steps and the information, conclusions and results of each step thereby preparing the WSP. Once the WSP has been

prepared it should be put in place as quickly as possible and it should be reviewed from time to time and reviewed immediately if there has been any significant change of circumstances in any part of the water supply chain or if there has been a problem with the quality of the water supply.

The following sections give brief guidance on the preparation and content of WSPs for each element of the water supply chain. The guidance is not intended to be fully inclusive and more detailed and comprehensive guidance can be found in the World Health Organisation's Guidelines for Drinking-water Quality, Third Edition, Volume 1, Recommendations and Water Safety Plans: Protecting Drinking-water Quality from Catchment to Consumers.

Catchment and Raw Water Source Protection

It is essential to collect relevant information about the nature of the catchment and the activities taking place in the catchment and about the nature and quality of the raw water source as part of a WSP. Examples of the information required are:

Catchment

- geology, hydrology, meteorology and weather patterns
- nature of the land and it use, in particular degree of urbanisation, industrial activities, animal rearing and arable farming, degree of natural land and its wildlife, quarrying and mining (that is uses and activities that could give rise to contamination of raw water sources)
- competing water uses such as irrigation and river compensation flows
- planned future activities
- any existing catchment control and protection zones

Surface water

- type of water such as river (direct abstraction), river (abstraction in storage reservoir), impounding reservoir, lake
- inventory of point discharges such as sewage effluents, industrial effluents, water from mining
- water quality and how it varies seasonally and with weather patterns
- flow and reliability of source and retention time if stored
- recreational and other human activity
- any existing source protection systems

Groundwater

- confined or unconfined aquifer, hydrology and recharge area
- flow rate, direction of flow and dilution characteristics
- whether fast or slow response to activities and events on surface
- depth of casing and abstraction and any wellhead protection
- inventory of activities in the recharge area that could affect water quality

Hazard identification

The next step in the preparation of a WSP is to identify the hazards that arise in the particular catchment. Some examples of typical hazards are:

- rapid variations in raw water quality arising from meteorological effects and activities within the catchment
- pollution of raw water from point discharges such as sewage, septic tank and industrial effluents, storm water overflows, overflows from active and closed mines and landfill sites
- pollution from agricultural activities including chemicals and fertilisers from arable land/forestry and wastes from animal rearing
- pollution from human recreational activity and wildlife
- inadequate protection of the source and its point of abstraction
- short-circuiting, stratification and eutrophication of raw water storage reservoirs

Risk assessment

The next step is to assess the risk associated with each identified hazard. There are two aspects to assessing the risk. The first is the likelihood of the hazard or hazardous event occurring, taking into account existing catchment controls and treatment processes and controls, and it could be described qualitatively in terms such as almost certain, likely, moderately likely, unlikely or rarely or by a quantitative scoring method. The second is the severity of the consequences of the hazard should it occur, particularly the effect on human health and meeting health based standards and indicator parameter values. Again this assessment could be described qualitatively in terms such as catastrophic, major, moderate, minor or insignificant or by a quantitative scoring method. The risk associated with each hazard is a combination of the likelihood of occurrence and the severity of the consequences. The risks can then be ranked in priority for action, but not all will require attention because some will be very small.

Control measures

The next step is to identify the control measures in the catchment or at the point of abstraction that will reduce or eliminate the risk. It should be noted that some risks cannot in practice be controlled by these measures and can only be controlled by appropriate treatment processes. Examples of typical control measures are:

- implementing a catchment management plan that includes measures to protect surface and groundwater such as
    - controls of all point sources of effluent or overflows discharging to the catchment
    - site specific protection requirements, such as containment for industrial chemicals and agricultural slurries
    - designation, limitation and control of specific activities or uses with all or part of the catchment
    - regular inspection of the catchment
- planning regulations include protection of water resources against future activities
- protection at the point of abstraction such as
    - security to prevent unauthorised access or tampering by humans or animals
    - appropriate arrangements for surface water abstraction from rivers, reservoirs and lake and for wellhead and casings for groundwater abstraction

- reservoir management to minimise eutrophication , short-circuiting and stratification.

Validation and monitoring of control measures

Each control measure should be subject to intensive validation monitoring where possible and to routine monitoring to check that it is working. For example a sewage works or industrial effluent should be subject to a discharge consent (for example set by an environmental regulator) that specifies quality criteria that must be met. The sewage works or industrial operator should be required to monitor effluent quality on a regular basis and should be required to notify the water supplier and the environmental regulator should the quality criteria not be met. For many of the above control measures the monitoring will be by regular inspection of the catchment and potential polluting sites and regular inspection of the point of abstraction and associated works.

Treatment Works

After dealing with the WSP for the catchment and raw water source part of the water supply chain, the next part of the chain is the water treatment works. First it is necessary to collect relevant information about the existing treatment works and its operational control. A flow diagram of the existing processes and their controls is essential. Examples of the information required are:

- details of each treatment process (including optional processes) and which contaminants or potential contaminants they are designed to remove
- details of the control of each treatment process (monitoring parameters and whether discrete, continuous, automatic, manual) and the criteria for deciding that each process is in control and working efficiently
- disinfection contact time and disinfection residuals
- operational control and monitoring of the final treated water to check that overall treatment is working efficiently
- details of chemicals used in the treatment processes
- any hazards identified in the assessment of the catchment that cannot be controlled in the catchment and may not be removed by existing treatment processes

Hazard identification

The next step is to identify the hazards that might arise during the treatment process. Some examples of typical hazards are:

- any contaminants identified as hazards in the catchment that are not controlled within the catchment and may not be removed by existing treatment processes
- flow and quality variations outside design limits
- failure of any treatment process for example caused by equipment malfunction or breakdown
- inappropriate or insufficient treatment or insufficient back up equipment
- failure of process monitoring equipment and alarms
- natural disasters and power failures
- contamination problems arising from water treatment chemicals and materials including the formation of unacceptable levels of disinfection by-products

Risk assessment

The next step is to assess the likelihood risk and severity of risk associated with each identified hazard and rank those risks in priority order. An example of a common hazard and risk is sporadic high turbidity in the raw water. This can overwhelm the treatment processes, including disinfection, and allow enteric pathogens to enter supply with the consequent risks to human health.

Control measures

The next step is to identify the control measures that need to be applied at the treatment works to reduce or eliminate the risk. Examples of typical control measures are:

- new or upgraded treatment processes to ensure that all hazardous contaminants are adequately removed, including any standby or back up processes/equipment
- optimise each process to achieve the desired level of removal
- stopping abstraction or diverting raw or treated water during periods of less than optimal quality
- using only approved water treatment chemicals and materials and using them appropriately and checking their quality
- systems to detect process or equipment failure linked to appropriate alarms and for serious failures shut down of the works.
- treatment systems to remove substances that cannot readily be controlled within the catchment and are difficult to monitor routinely such as *Cryptosporidium* and endocrine disrupting chemicals

Validation and monitoring of control measures

Each treatment process should be subjected to intensive validation monitoring and routine monitoring to check that it is working efficiently and optimally. Each monitoring system should have preset limits which if exceeded trigger an alarm meaning that the process is not operating correctly and it needs immediate investigation and in appropriate cases works shut down. For example there should be a continuous nitrate monitor on a nitrate removal process which if exceeds a level slightly below the health based standard triggers immediate investigation, but not works shut down. Another example is that there should be a continuous disinfectant residual monitor on the water entering supply which if it falls below a specified level would trigger immediate investigation and, depending on the circumstances, works shut down to prevent harmful pathogens entering supply. Some monitoring could consist of frequent physical checks on equipment and routine servicing and maintenance.

Distribution networks

After dealing with the WSP for catchment, raw water and treatment works parts of the water supply chain, the next part of the chain is the distribution system. First it is necessary to collect relevant information about the distribution network, including any service reservoirs, and its operational control. A schematic diagram of the network, any service reservoirs and their controls (valves, hydrants etc), is essential. Examples of the information required are:

- service reservoir design (capacity, number of compartments, position of inlets/outlets), materials of construction and retention time
- protection from unauthorised human and animal access to service reservoirs, such as enclosures, hatch covers, and from surface water ingress
- materials of the network including any internal linings
- normal range of pressures, flows, water age and retention time
- normal method of operation and permitted variations to suit varying demands for water
- condition of distribution network (structural - frequency of bursts, water quality – deposits, microbiological growth)

Hazard identification

The next step is the identification of the hazards that might arise during the distribution of water to consumers. Some examples of typical hazards are:

- infiltration/ingress of contaminated surface/subsurface water through structural defects in a service reservoir or through low or no pressure in a network
- ingress of contaminated water or other material when a reservoir or network is opened for repair for example dealing with burst mains
- back flow of contaminated water from consumers' premises during periods of low or no flow
- leaching of chemicals from the use of inappropriate materials in the network
- build up of deposits and microbiological growths in the reservoir or network through ineffective water treatment, corrosion or ineffective operation
- unauthorised tampering at service reservoirs and in the network including illegal connections to hydrants
- migration of petrol and other solvents through plastic pipes

Risk assessment

The next step is to assess the likelihood risk and severity of risk associated with each identified hazard and rank those risks in priority order. An example of a common hazard and risk is the supply of discoloured water resulting from disturbance of deposits in the network.

Control measures

The next step is to identify the control measures that need to be applied at the service reservoir or within the distribution network to reduce or eliminate the risk. Examples of typical control measures are:

- operate the network in a way that minimises sudden changes in flow thereby reducing the risk of discoloured water and practise routine controlled flushing
- maintain adequate network pressures
- have written procedures for conducting repairs (such as burst mains) that involve opening the network that include appropriate disinfection before reconnection to supply
- maintain a disinfectant residual throughout the network (if possible) to reduce microbiological growth
- know the status of all valves (open/closed)
- carry out a risk assessment of the consequences of any major change in the operation of the network before authorising the operation

- only approved materials should be used in the network

Validation and monitoring of control measures

Each control measure within the distribution system should be validated and monitored to check that it is working properly. For example the flow, pressure and disinfectant residual should be monitored at various points within the network with immediate investigation when the result is outside specified limits. There should be internal audits periodically to check that staff are following procedures for conducting repairs to burst mains. Some monitoring, for example, should be regular inspection and maintenance of service reservoirs and the distribution network and regular inspection of petrol storage sites such as garages.

Consumers' Installations

The final part of the water supply chain is the consumer's domestic distribution system to the tap or taps normally used for human consumption. It is generally not practical for a water supplier to maintain information about each consumers' system. However, some information about consumers' installations generally within the water supply area is useful. Examples are

- number of connections broken down into useful categories such as industrial, commercial, domestic households
- details of major industrial and commercial sites including information about water distribution within the site
- estimates of the proportions of major plumbing materials likely to be found within domestic households such as lead, copper, galvanised iron, polyethylene.

Hazard assessment

There are two major hazards to be considered. The first is the possibility of backflow of contaminated water from a consumer's installation into the distribution network thereby causing the supply of contaminated water to consumers downstream. The second is the effect of the pipe work and fittings of the quality of water issuing from the taps normally used for human consumption. For example metals and other substances may leach from the pipe work into the water (e.g. lead) and micro-organisms may be introduced into the water by poor hygienic conditions, particularly from taps.

Risk assessment

The next step is to assess the likelihood risk and severity of risk associated with each identified hazard and rank those risks in priority order. Clearly any risk of backflow from a major industrial site could have very severe consequences for downstream supplies. If very few properties have lead pipe work, the risk of leaching lead is very low; however if many properties have lead pipe work the risk of leaching lead is high, but may be reduced if plumbosolvency control by treatment is practised.

Control measures

The next step is to identify the control measures that need to be applied to reduce or eliminate the risk from consumers' installations. Examples of these are:

- treat the water with appropriate chemicals at the treatment works to reduce the tendency for water to leach metal for the consumers' pipe work
- an education campaign (e.g. leaflets) to inform consumers of the risks to their own water supply from their pipe work materials and from unhygienic taps with advice on how to minimise or eliminate such risks.

Validation and monitoring the control measures

Each control measure should be validated and monitored to check that it is working properly. For example there should be regular inspection of premises to check that the consumers' installations have appropriate back flow prevention devices fitted, with more frequent inspections of the higher risk premises. If treatment is practised to reduce metal solvency, appropriate parameters (such as pH value, alkalinity, phosphate) should be monitored in the water leaving the works and within distribution to check that the water is properly treated. Periodic surveys of consumers is a useful way of monitoring whether they understand and minimise the risks from their own installations.

Validation Monitoring

Once the WSP has been prepared for the whole water supply chain, it is necessary to prepare a routine validation monitoring programme including what is monitored and how frequently, to check that the WSP is working, that system units are working as assumed in the system assessment and the water being supplied is safe and meets the health based standards, and other requirements.

The sampling points for validation monitoring programmes in a water supply chain should be taps normally used for human consumption selected to be representative of the premises and establishments within that water supply chain. When it has established that the distribution network or the domestic distribution system does not affect the value for a parameter, the sampling point for that parameter can be the exit from the treatment works or other appropriate point in the water supply chain.

The basic parameters requiring monitoring and the annual frequency of sampling for each parameter for each water supply chain are currently set down in Regulations. Additional requirements should be determined by the water safety plan. Ideally parameters do not need to be included in the routine validation monitoring programme for a particular water supply chain where it has established through the water safety plan that those parameters are unlikely to be present or are present at values well below the standards or target values set but currently this is not the regulatory position.

Examples of the parameters that might be included in a routine validation monitoring programme are:

- Disinfectant residual, coliforms, *E. coli*, and colony counts to check the microbiological quality at taps
- Lead, copper, nickel, arsenic, chromium to check whether these metals have leached from consumers' installations
- Quantitative (and qualitative) taste and odour to check that the condition of the distribution network and consumers' installations do not give rise to these problems

Other parameters may need to be included in some circumstances, but generally most parameters need not be included in a routine programme because they should be adequately covered by the control measures put in place under the WSP and the routine operational monitoring of those control measures.

Supporting programmes

Some examples of supporting programmes are:

- Train appropriate staff in all aspects of preparing and implementing a WSP
- WSPs require numerous operational procedures – these should be written as for example standard operational instructions
- Quality control of as many aspects of a WSP as possible – for example all measurements of control measures should be subject to appropriate quality control procedures, such as internal and external analytical quality control within laboratories.

Documentation

All the above elements that contribute to the WSP should be fully documented to form the WSP. A WSP should be reviewed immediately when there is a significant change of circumstances within, or a problem with, the water supply chain. A WSP should also be reviewed from time to time, particularly taking into account the results of implementing the WSP. Any changes made to a WSP as a result of a review should be documented.

Independent Surveillance – Verification

There should be **independent verification** from time to time by an approved person or organisation who is not under the control of the organisation that prepared the water safety plan using appropriate systems of audit and inspection, that the organisation (usually the water supplier) has prepared its water safety plans in accordance with this guidance and good water supply practice and has established appropriate validation monitoring programmes based on those plans.

Such an approved person or organisation may also carry out some independent surveillance by carrying out sampling and analysis to check that the water supply is safe and meets health based standards and other regulatory requirements.

Another example of independent verification is that any laboratory analysing samples as part of a WSP should have its system of analytical quality control checked from time to time by an approved person or organisation who is not under the control of the laboratory.