Participant **workbook**

Water Safety Plans – Training package

World Health Organization

International Water Association

International Water Association (IWA)

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WSP Participant Workbook

Contents

Glossary of terms and abbreviations

Audit – review and evaluation of WSP practice

Catchment – drainage basin / watershed – a discrete area of land that has a common drainage system. A catchment includes both water bodies that convey the water and the land surface from which water drains into these bodies (Helmer & Hespanhol, 1997).

Compliance – adherence to set water quality / operational requirements

Control measure – any action or activity that can be used to prevent, eliminate or reduce to an acceptable level any water safety hazard

Control point – A step at which control can be applied to prevent, eliminate or reduce the risks of a water safety hazard

Corrective action – any action to be taken when critical limits are exceeded

Critical limit – a criterion that separates acceptability from unacceptability

HACCP (hazard analysis and critical control points) – a system that identifies, evaluates and controls hazards that are significant for food safety

Hazard – any agent (physical, chemical, biological or radiological) that can cause harm to public health

Hazardous event – any process that introduces hazards to, or fails to remove them from, the water supply

Implementation (of WSP) – putting a WSP into practice

Incident/near-miss – where loss of control has led to (or narrowly missed) a public health risk

IWA – International Water Association

Monitor – the act of conducting a planned sequence of observations or measurements of control parameters to assess whether the control point is under control or whether the water meets quality criteria

Multi-barrier approach – the concept of using more than one type of barrier or control measure in a water supply system (from catchment through abstraction, treatment, storage and distribution to the consumer) to minimize risks to the safety of the water supply

Operational monitoring – The act of conducting a planned sequence of observations or measurements of control parameters to assess whether a control measure is operating within design specifications

Operational step – a point, procedure, operation or stage in the water supply process

Organizational culture – attitudes, experiences, norms, beliefs and values of an organization

Point of use – point of consumption

Regulator – organization responsible for ensuring that water supply meets specified statutory requirements

Risk – the likelihood of identified hazards causing harm to exposed populations in a specific time frame and the magnitude and/or consequences of that harm

Stakeholders – individuals or organizations that are influenced by, or influential to, the water supply

Supporting programmes – actions that are important in ensuring drinking-water safety but do not directly affect drinking-water quality (e.g. training and management practices)

Upgrade – improvement (to supply system)

Validation – investigative activity to identify the effectiveness of control measures. It provides the evidence that elements of the WSP can effectively meet the water quality targets

Verification – the application of methods, procedures, tests and other evaluations to determine compliance with the WSP. Verification confirms that the water quality targets are being met and maintained and that the system as a whole is operating safely and the WSP is functioning effectively.

Water safety plan (WSP) – a comprehensive risk assessment and risk management approach that encompasses all steps in water supply, from catchment to consumer

WHO – World Health Organization

Introduction

This workbook is designed to be used by participants attending a water safety plan (WSP) training workshop that has been organized around the materials developed by the International Water Association (IWA) and World Health Organization (WHO). The learning material included in this workbook relates explicitly to the theory sessions that will be presented and the designed exercises. It therefore cannot be used as a standalone document to train people on all WSP aspects.

WSPs are a risk-based approach to most effectively protect drinking-water safety. WHO's 4th edition of the *Guidelines for drinking-water quality* (WHO, 2011) explicitly states the importance of WSPs, and the Bonn Charter (IWA, 2004) advocates the use of WSPs as the best way of ensuring good, safe drinking-water.

WSPs are now being adopted worldwide, but they are not always fully understood by all stakeholders. There are a number of key terms and concepts that are not always translated appropriately or are simply misunderstood. Face-to-face training is therefore considered to be an essential component of globally successful WSP implementation.

The workshop is structured around 13 learning modules. The first module (Introduction) gives an overview of WSPs. The last module (Module 12) introduces participants to the quality assurance tool for WSPs (WHO & IWA, 2012). Modules 1–11 relate explicitly to the WSP manual produced by IWA and WHO (Bartram et al., 2009), from which the workshop is designed.

How to use this workbook

The workbook is structured into 13 modules. Within each module, the learning objectives, key points and exercise details are included. The workbook is designed to be used during the theory sessions and group work. Therefore, "answers" are not given to topics discussed during the workshop, but instead space is made available for the participant to summarize key points from any given activity.

Icons are used throughout the workbook as a guide to the participant on the type of activity. For example, the following informs the participant that there will be a discussion on how catchment control measures are assessed:

How can catchment control measures be assessed?

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Icon	**Meaning**
	Question mark: question is asked. Write answers in workbook
	People: group work/activity
	People with speech bubble: discussion time
	Two people: work in pairs
	Flipchart: some information is recorded on a flipchart – transfer to workbook if desired
	One person: individual work

Competence wheel exercise (Part I)

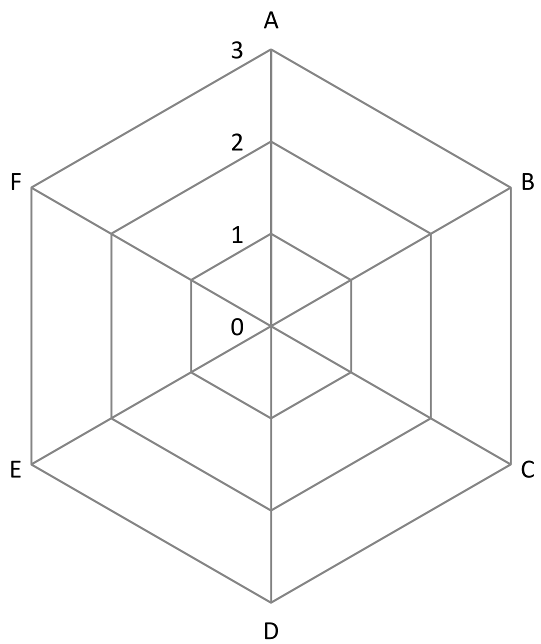
Score your agreement with the following six statements (A–F). This is for your own use only. The exercise will be completed again later on in the workshop.

A. I have a thorough understanding of what is involved in WSP design and implementation.
B. I know what hazards and hazardous events are likely to occur in the water supply system where I work.
C. I have a thorough understanding of the complexities of risk assessment and know of the two main approaches.
D. I know how a WSP is used to steer financial investments within the utility where I work.
E. I know what a control measure is and how it is used, monitored and validated.
F. I know when a WSP should be reviewed and amended.

For each question, assign a score between 0 and 3:

0 = No understanding and/or not heard of
1 = Little understanding and/or could not apply in practice
2 = Good understanding and/or could apply in practice
3 = Complete understanding and/or have applied in practice and/or could train others

Enter your scores on the wheel diagram below.



Learning material

WSP introduction (Module 0)

Learning objectives

Through active participation in and successful completion of the introductory module, each participant should be able to meet the following learning objectives:

- Explain that a WSP is a source to point-of-use risk management approach that exists within a wider framework for safe drinking-water.
- Explain why the traditional end-product monitoring approaches are insufficient for ensuring drinking-water safety.
- Elaborate on why the WSP approach was developed and why it is needed.
- Clearly communicate the WSP approach as outlined in the WHO/IWA WSP manual.

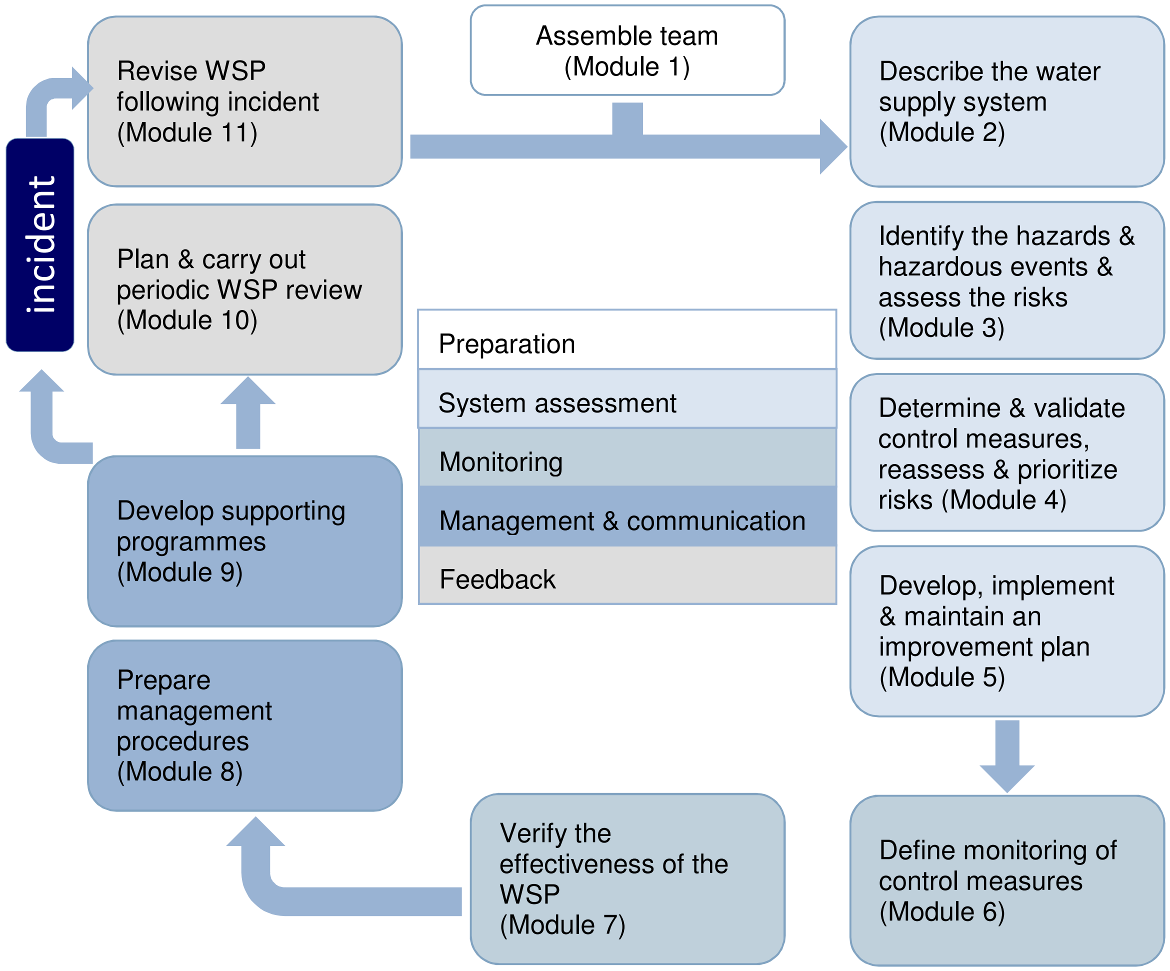


Figure 0.1 – WSP steps

Key references:

- Bartram et al. (2009) *Water safety plan manual*
  http://www.wsportal.org/wspmanual
  http://www.who.int/water_sanitation_health/publication_9789241562638/en/index.html
- IWA (2004) *Bonn charter for safe drinking water*
  http://www.iwahq.org/cm

- WHO (2011) *Guidelines for drinking-water quality,* 4th edition
  http://www.who.int/water_sanitation_health/dwq/guidelines/en/index.html
- WHO (2012) Water safety plan quality assurance tool v1.3 (Excel tool and manual)
  http://www.wsportal.org/templates/ld_templates/layout_1367.aspx?ObjectId=20686&lang=eng
  http://www.who.int/water_sanitation_health/publications/wsp_qa_tool/en/index1.html
- WSPortal (tools and case-studies)
  http://www.wsportal.org

Key points

Principles and features

- WSPs are based on risk management principles from other approaches, including HACCP (hazard analysis and critical control points) and the multi-barrier approach.
- The WSP approach is applicable to all types of water supply systems.
- End-point monitoring is still important in verifying drinking-water safety. However, a complementary approach is also needed to lower the risk of contaminants from entering drinking-water supplies in the first place to better protect consumers.
- WSPs involve preventive risk analysis and risk management from catchment to point of use.
- The public's health can be protected by knowing the supply system thoroughly, understanding utility staff roles, being aware of what problems may occur and taking action to control those problems to result in more consistent supplies of safe drinking-water.
- WSPs require an understanding that is beyond the "technical" aspects (e.g. managerial, training and incident response).
- WSP objectives are to:
  - Minimize contamination in source waters
  - Reduce or remove contamination by treatment
  - Prevent contamination during storage, distribution and handling.
- The development and implementation of WSPs are a continuous incremental process, with improvements made over time according to the significance of the risks, available resources, knowledge and as required. Some utilities may be more experienced in identifying and managing risks (i.e. risk "mature") than others, but each can improve, and should improve, continuously over time at a suitable pace.
- Multiple barriers (more than one control measure) should be put in place from the catchment to the point of use so that if one control measure is insufficient, other control measures are in place to minimize the risks to the safety of the water supply.
- WSPs should not be considered additional work; they provide a new way to do work more efficiently and effectively.
- There are five stages of a WSP (Figure 0.1):
  1. Preparation
  2. System assessment
  3. Monitoring
  4. Management and communication
  5. Feedback
- The WHO/IWA WSP manual describes a modular 11-step approach, on which this training package is based (Figure 0.1).

Benefits

- A key benefit of WSPs is that utility staff become more aware of their role in the provision of safe drinking-water.
- Other benefits may include cost savings (e.g. by reducing or eliminating any unnecessary monitoring and testing, reducing the need for treatment or improving maintenance), improved communication/ stakeholder relationships and management and operation of the utility.

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Why are traditional ways of ensuring water safety not enough?

Read through the London cholera case-study. Discuss points of interest.

London – 1854 In the 19th century, London was the largest city in the world, with serious overcrowding issues. The Soho district had serious sanitation problems. There was no sewerage system, and most properties had cesspools beneath their cellars that were overflowing. The government decided to dump this waste into the River Thames, which contaminated the drinking-water supply and led to a number of cholera outbreaks. A physician, John Snow, with the help of the Reverend Henry Whitehead, made the connection between these outbreaks and a contaminated water supply.

On 31 August, a major cholera outbreak affected Soho. Over the next three days, 127 people near Broad Street, Soho, died. The following week, three quarters of the residents had fled the area. By 10 September, 500 people had died, and the mortality rate was 13% in some areas of the city. By the end of the outbreak, 616 people had died.

The dominant theory at the time was that diseases such as cholera were caused by air pollution. This unfortunately spurred on the practice of dumping raw sewage from cesspools into the Thames, in order to "clean" the air around living areas. At the time, the germ theory was not widely accepted. John Snow believed that cholera was spread via the water.

By talking to local residents, he identified the source of the outbreak as the public water pump on Broad Street. Although Snow's chemical and microscopic examination of the water was not able to prove its danger, his studies of the pattern of disease were convincing enough to persuade the local council to disable the pump.

Snow used a spot map to illustrate how cases of cholera were centred around the pump. It was discovered later that this Broad Street pump well had been dug only three feet from an old cesspit and was being contaminated from a domestic sewer pipe. He used statistics to illustrate the connection between the quality of the source water and cholera cases.

Despite Snow's efforts, it was not until 1858, when the stench of the polluted Thames was unbearable, that the germ theory of disease was considered. Parliament sanctioned one of the century's great engineering projects – a new sewer network for London, which opened in 1865.

Exercise – Introductory module

Aim: To reinforce the public health role of suppliers and remind participants of what the potential health impacts would be within the population if treatment were to fail or were insufficient to remove such contamination, thus highlighting the need for an effective WSP

Timing: 15 minutes

Structure: Groups of four

Feedback: Swap tables and mark other group's work

Complete the missing sections of Table 0.1 using the possible answers below. Complete the laminated table provided. After 15 minutes, you will be asked to swap tables with another group to mark each other's work.

Possible answers:

- Lead
- *Escherichia coli*
- Dysentery
- Faecal contamination
- Diarrhoea and intestinal malabsorption
- Occurs naturally, grows well at high temperatures
- *Legionella pneumophila*
- Too much: adverse changes in bone structure
- *Cryptosporidium parvum*
- Liver damage, neurotoxicity and possibly tumour promotion
- Cholera (severe diarrhoeal disease)
- Addition during treatment and naturally in the environment
- Skin changes and cancers of the skin, lung and bladder (after long term exposure)
- Occurs naturally and in certain human-made installations such as water cooling devices and spas
- Faecal contamination

Table 0.1 – Incomplete table of parameters and their impact on health

Parameter	Potential health impact	Potential source (in water)
	Diarrhoea	Faecal contamination (indicator for faecal contamination)
Shigella spp.		
Vibrio cholerae		
	Diarrhoea	Faecal contamination
Giardia intestinalis		Faecal contamination (wide range of animal species)
Naegleria fowleri	Amoebic meningitis (via inhalation)	
	Pneumonia (via inhalation)	
Fluoride		
Arsenic		
	Adverse neurological effects	Old pipes and plumbing
Cyanobacterial toxins		Bacterial blooms in raw water

Module 1 – Assemble the WSP team

Learning objectives

Through active participation in and successful completion of Module 1, each participant should be able to meet the following learning objectives:

- Demonstrate clear understanding of the purpose of the WSP team and therefore who should be involved in WSP development and implementation.
- Explain why engagement of senior management from the outset is of vital importance.
- Evaluate the relative importance of all WSP stakeholders with regard to ensuring the delivery of safe drinking-water.
- Identify the expertise needed to design and implement an effective WSP with clearly assigned roles.

Key points

- A WSP team should be formed to own and lead WSP development and implementation efforts and to advocate the approach to those connected with the safety of the water supply.
- A WSP team is largely made up of people from within the water utility, but, if required, external stakeholders and consultants may be approached for their expertise. Any requirement for new staff or external advisory input should be identified early on.
- In order for WSPs to be implemented successfully, senior management buy-in is needed from the outset to support changes in work practices and provide financial and resource support.
- A team leader needs to be appointed to ensure focus.
- Members of the team must have appropriate authority to implement recommendations that result from the WSP.
- Team members must be skilled in risk management and collectively have knowledge of the entire supply chain. It is essential that the expertise needed is matched to a person responsible and that all roles are clearly defined.
- Key members will vary according to the context, but will likely include in-house operators, engineers, scientists, risk managers, technicians, external regulators, environmental agencies and landowners.
- Information about the WSP team members (e.g. name, job title, role within the WSP team and contact details) must be recorded and updated as necessary (see Table 1.1).
- The size of the team should depend on the size of the organization and complexity of the system (a small team is better than no team). For further information, see example/tool 1.3 in the WSP manual.
- The initial time input for WSP development and implementation may be high, but it will decrease over time as the WSP team becomes more familiar with the WSP process.
- Team development poses a number of challenges: finding skilled personnel, organizing the workload, identifying and engaging external stakeholders, keeping the team together and effective communication.

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Table 1.1 – WSP team details form

Name	Affiliation	Title	Role within team	Contact information
Name of employee	*Organization*	*Job title*	*What is the employee responsible for?*	*Telephone number and email address*

Why should you assemble a team?

Why do we need to engage senior management?

Are there any additional external support resources you could engage?

How could you overcome the challenges presented?

The main outputs from Module 1 will be the establishment of a multidisciplinary team that understands the supply system, is well placed to assess the risks associated with the system and has authority to implement recommendations resulting from a WSP.

Exercise – Module 1

Aim: To identify key competencies required for WSP teams and create a list of potential contacts

Timing: 25 minutes

Structure: Groups of four

Feedback: Groups verbally provide feedback to workshop

Group together with other members of the same utility (if there are only single participants from each utility, then groups may discuss together, but prepare individual lists). List an ”ideal” WSP team from within your utility. On a flipchart, write down job titles and names if you know them, the expertise they will bring to the team, contact information and back-up contact details. Identify what expertise is missing, and make suggestions of who you could ask to help source this expertise. Are there any external stakeholders that should be approached?

Nominate a rapporteur and someone to provide feedback to the main group at the end of the exercise. Lists produced can be taken back and used as a starting point for recruiting potential WSP team members.

Module 2 – Describe the water supply system

Learning objectives

Through active participation in and successful completion of Module 2, each participant should be able to meet the following learning objectives:

- Identify what factors need to be considered when describing a water supply system.
- Design and construct an interlinked flow diagram of system components (from source to point of use) for a known system.
- Formulate a list of common challenges encountered when describing a system.

Key points

- It is necessary to describe *each* supply system in order for subsequent risk assessments to be carried out with confidence.
- The entire system (from catchment to point of use) needs to be described, with the final uses and users identified. These should also explicitly state what and who the water is not suitable for.
- The supply system should be described relative to the water quality standards required, which are based on the local health-based targets.
- Site visits as well as document analysis will be required for an effective description.
- Descriptions (module outputs) will include personnel, system flow diagram, water quality information (treated and untreated) and expected deviations due to changes in weather conditions.

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Items to include in a water supply system description

Catchment: ____

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Treatment: ____

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Distribution: ____

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User: ____

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What areas of the system do utilities not have direct control over? For these components, what activities can utilities partake in, to support water safety?

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Typical parameters that may be measured with regard to water quality include:

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Possible challenges that might be faced when describing a supply system:

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The main output from Module 2 will be a detailed, up-to-date description of the water supply system that includes a system flow diagram, water quality information (treated and untreated), expected deviations in source water quality due to changes in weather conditions, an identification of the uses and users of water and availability of trained staff.

Exercise – Module 2

Aim: To describe a known water supply system and document as a flow diagram

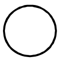
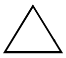
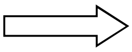
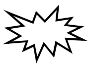
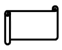
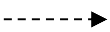
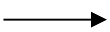
Timing: 25 minutes

Structure: Groups of four

Feedback: Swap tables and review another group's flow diagram, and provide feedback to the workshop after the exercise

Create a basic flow diagram of a water supply system known to you or a member of your group. Use the symbols (shown below) to define each step. The system should be described from catchment to point of use, with notes made (star) where the system is unknown/not known in sufficient detail. In these situations, you should identify how this information will be obtained, including identification of relevant stakeholders to provide this information.

To supplement the flow diagram, reference should be made to other documentation (banner symbol) that would provide more information, e.g. treatment works process flow diagram.

	Circle = Operational step
	Triangle = Storage step
	Block arrow = Transport step
	Star = Unknown part of system
	Banner = Refer to other documentation
	Dashed line arrow = Intermittent process
	Full line arrow = Continuous process
BOLD/Blue	Bold/Blue = Utility control
UNBOLD/Red	Non-bold/Red = Outside of utility control

Module 3 – Identify hazards and hazardous events and assess the risks

Learning objectives

Through active participation in and successful completion of Module 3, each participant should be able to meet the following learning objectives:

- Explain the stages and meaning of hazard identification and risk assessment.
- Undertake risk assessments of given hazards/hazardous events.
- Identify vulnerable areas or processes in a water supply system.
- Outline the common challenges associated with the use of risk assessment methods.

Key points

- In practical terms, Module 3 is carried out concurrently with Modules 4 and 5 and forms part of the system assessment.
- Definitions:
  - Hazard – any agent (physical, chemical, biological or radiological) that can cause harm to public health.
  - Hazardous event – any process that introduces hazards to, or fails to remove them from, the water supply.
  - Risk – the likelihood of identified hazards causing harm to exposed populations in a specific time frame and the magnitude and/or consequences of that harm.
- The first component of Module 3 is to identify potential hazards and hazardous events and then to assess their risk.
- Identifying hazards and assessing risks will likely involve site visits, but should also be carried out by reviewing the system description (including the flow diagram), historical data and predictive information.
- Risks can be assessed either quantitatively or qualitatively. For example:

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- It is essential that the risk matrix used is tailored to the local context. For example, detailed definitions for the severity and likelihood categories should be developed based on the local context. The risk matrix score that identifies significant risks should also be defined. There is no one way to conduct the risk assessment. Regardless of the methodology that is adopted, it is important to be consistent in the assessment approach (e.g. the likelihood and severity scoring criteria) to enable meaningful prioritization of the risks.

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What are some generic hazards found within each stage of a water supply system?

Catchment: ____

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Treatment: ____

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Distribution: ____

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User: ____

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How would you be able to determine what might go wrong with the water supply system?

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Algal blooms in reservoir – example risk score

In your groups, assess the risk of algal blooms and designate a score. Remember to record the rationale for the risk assessment score.

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The Module 3 outputs are essentially to describe what could go wrong and where and to assign a risk score.

Exercise – Module 3

Aim: To assign raw risk scores for three given hazardous events and appreciate how difficult it is to be consistent in such assessments

Timing: 25 minutes

Structure: Groups of four

Feedback: Verbal feedback to workshop after exercise

Identify the hazard and hazardous event and assess the risks for the three given examples, assigning a raw risk score. Note how and why you came to that score and be prepared to feed back this rationale to the workshop after completing the exercise. An example risk assessment matrix is shown in Figure 3.1. Answers should be recorded on a flipchart; refer to the examples for guidance.

Note: Summary handouts of the case-studies from which these hazardous event examples are taken are available from the facilitator on completion of the exercise.

Hazardous event 1 – Score the raw risk of microbial pathogens not being removed from the source water due to failure of a chlorine dosing pump using the risk matrix provided.

Hazardous event 2 – Score the raw risk of water main breaks and ingress of pathogens and soil into water mains during repair using the risk matrix provided.

Example 1	**Chlorine dosing pump breaks down at a chlorination-only treatment facility. Based on records, this occurs once every two weeks. Untreated water enters the water distribution system and reaches some customers.**
Hazardous event	Brief description of the hazardous event
Hazard	What is the hazard?
Likelihood of hazardous event	If there are no controls in place, what is the likelihood of contamination during a dosing pump failure? What is the rationale for the likelihood score?
Severity or consequence	What is the severity or consequence if pathogens enter the water distribution system and reach the customers? What is the rationale for the severity score?
Raw risk score	Calculate the raw risk score based on the likelihood and severity ratings.

Example 2	**Water main breaks (bursts) at least once a week in a distribution system. A work crew attends the burst site, repairs the main and restores the water supply.**
Hazardous event	Brief description of the hazardous event
Hazard	What are the hazards?
Likelihood of hazardous event	If there are no controls in place, what is the likelihood of contamination of the water distribution system due to the repair works? What is the rationale for the likelihood score?
Severity or consequence	What is the severity or consequence if pathogens enter the water distribution system and reach the customers? What is the rationale for the severity score?
Raw risk score	Calculate the raw risk score based on the likelihood and severity ratings.

		Severity or Consequence				
		Insignificant or no impact - Rating: 1	Minor compliance impact - Rating: 2	Moderate aesthetic impact - Rating: 3	Major regulatory impact - Rating: 4	Catastrophic public health impact - Rating: 5
Likelihood or frequency	Almost certain / Once a day - Rating: 5	5	10	15	20	25
	Likely / Once a week - Rating: 4	4	8	12	16	20
	Moderate / Once a month - Rating: 3	3	6	9	12	15
	Unlikely / Once a year - Rating: 2	2	4	6	8	10
	Rare / Once every 5 years - Rating: 1	1	2	3	4	5

Risk score	<6	6-9	10-15	>15
Risk rating	Low	Medium	High	Very high

Figure 3.1 – Example semiquantitative risk assessment matrix

Module 4 – Determine and validate control measures, reassess and prioritize the risks

Learning objectives

Through active participation in and successful completion of Module 4, each participant should be able to meet the following learning objectives:

- Understand the terms control measure and validation.
- Identify typical control measures for all stages of a water supply system.
- In given examples, assess which measures are used to control certain hazards.
- Explain the processes involved in validating control measures.
- Discuss the challenges of prioritizing risks.

Key points

- In practical terms, Module 4 is carried out concurrently with Modules 3 and 5 and forms part of the system assessment.
- Module 4 contains four stages:

- Definitions:
  - Control measure – any action or activity that can be used to prevent, eliminate or reduce to an acceptable level any water safety hazard
  - Validation – investigative activity to identify the effectiveness of control measures. It provides the evidence that elements of the WSP can effectively meet the water quality targets.
- Validation (assessing effectiveness) is the process of obtaining evidence on the performance of control measures. It may require an intensive programme of monitoring during normal and exceptional operating conditions.
- The effectiveness of control measures should be based on long-term average performance and should inform where controls are substandard. The risks should be recalculated with a consideration of existing control measures and their effectiveness.
- Major challenges include:
  - Assessing control measure effectiveness (validation)
  - Uncertainty in prioritizing risks due to lack of knowledge and/or data to assess risks
  - Inconsistent risk assessment methodologies.

List of common control measures found in a water supply system

Catchment: ____

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Treatment: ____

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Distribution: ____

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User: ____

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Why is it important to assess risks with and without control measures in place?

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How can the effectiveness of catchment control measures be assessed (validation)?

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The Module 4 outputs are identification and validation of control measures, followed by a prioritization of insufficiently controlled risks.

Exercise – Module 4

Part 1 – Aim: To link hazardous events with control measures to mitigate risks

Timing: 5 minutes

Structure: Groups of four

Feedback: Facilitator to give "answers" after exercise – followed by brief discussion

Match up cards of hazardous events with suitable control measures. Then identify possible control measures for the three hazardous events listed below (and described further in Module 3):

1. Failure to disinfect due to chlorine dosing pump failure at the chlorination step
2. Contamination during repair of main breaks in the distribution system
3. Locally relevant example provided by facilitator

Part 2 – Aim: To promote deeper thinking about how control measures are validated.

Timing: 5 minutes

Structure: Groups of four

Feedback: Workshop discussions after exercise

Describe how each of the control measures included in the cards would be validated. Answers can be included in Table 4.1.

Part 3 – Aim: Reassess risks for the three hazardous events after considering the effect of control measures. Highlight how the likelihood and severity scores will change depending on the strength and effectiveness of control measures

Timing: 20 minutes

Structure: Groups of four

Feedback: Workshop discussions after exercise

Reassess the likelihood and severity by considering the effectiveness of existing control measures (assume control measures identified in Part 1 are currently in place). Record answers on flipcharts.

Table 4.1 – Control measures and possible methods of validation

Control measures	Possible validation methods

Module 5 – Develop, implement and maintain an improvement/upgrade plan

Learning objectives

Through active participation in and successful completion of Module 5, each participant should be able to meet the following learning objectives:

- Explain why an improvement/upgrade plan is required and what four activities are involved.
- Identify the factors that need to be considered when elevating the WSP cause to senior managers for financial investment of improvements/upgrades.
- Explain the challenges in developing/implementing and maintaining an improvement/upgrade plan.

Key points

- In practical terms, this module is carried out concurrently with Modules 3 and 4, forming part of the system assessment.
- An improvement/upgrade plan is needed if previous WSP steps have revealed that existing controls are not effective or are absent. This plan will prioritize the work that needs to be done.
- An improvement/upgrade plan can include short-, medium- and long-term programmes and should be implemented based on the significance of the risk and available resources.
- Each improvement or upgrade must be owned by a person for its implementation.
- Capital investment may be needed to upgrade parts of the supply system.
- A WSP should provide evidence for any required upgrade, which should result in proactive investment planning and reduced expenditure on unnecessary work.
- Introducing new controls may introduce new risks, hence the need to review the WSP accordingly.
- Improvements or upgrades should involve monitoring and reviews.

Review the example upgrade plan (Table 5.1 – reproduced from the WSP manual, page 54). In groups, invent another "action" and complete the rest of the row for this action, creating an improvement/upgrade plan.

What other factors need to be considered when developing an improvement/upgrade plan?

What are the main challenges when developing an improvement/upgrade plan?

The Module 5 outputs are the creation of a prioritized improvement/upgrade plan addressing each controlled risk; the implementation of short-, medium- and long-term activities for improvement/upgrade; and a process for monitoring the plan.

Table 5.1 – Example improvement/upgrade plan (from WSP manual, page 54)

Action	Arising from	Identified specific improvement plan	Accountabilities	Due	Status
Implement measures to control *Cryptosporidium*-related risks.	*Cryptosporidium* has been identified as an uncontrolled risk. Cattle defecation in the vicinity of an unfenced wellhead is a potential source of pathogen ingress, including *Cryptosporidium*, in wet weather. Currently, there is no confidence that these risks are adequately controlled.	Install and validate ultraviolet light treatment. Validation includes comparing theoretical treatment performance against that required to inactivate *Cryptosporidium* infectivity.	e.g. Engineer	e.g. Date the action should be completed by	e.g. Ongoing, not started, etc.
Implement measures to control risks arising from agricultural pesticides introduced into the water supply.	Risk assessment process has identified a cocktail of pesticides from agricultural uses. Currently, there is no confidence that these risks are adequately controlled.	Install ozone and granular activated carbon filtration within the water treatment plant. These controls should be validated through intensive monitoring and shown to continue to work through operational monitoring.	e.g. Engineer	e.g. Date the action should be completed by	e.g. Ongoing, not started, etc.
Review the need for and, if required, the options for reducing the risks from viral and protozoan water quality contamination from sewage systems to reduce risks to acceptable levels.	Risk assessment process has identified pathogen risks arising from sewage systems. Currently, there is no confidence that these risks are adequately maintained to acceptable levels by the control measures in place.	Develop additional sewage disinfection and downstream water treatment, including avoidance strategies as warranted.	e.g. Water quality officer	e.g. Date the action should be completed by	e.g. Ongoing, not started, etc.

Exercise – Module 5

Part 1 – Aim: To consider what methods and content of communication would be most suitable in a given context to raise awareness of water quality and health issues

Timing: 10 minutes

Structure: New groups of four

Feedback: Groups to present outline design to workshop using flipchart and pens

Evidence has been gathered from household surveys that show a lack of knowledge about safe water storage and the links between water quality, hygiene and health. In your **new** groups design and briefly outline a health awareness campaign for an area that is familiar to at least one member of the group. Present your outline on a flipchart.

Part 2 – Aim: To promote deeper thinking about how WSPs may be used to aid proactive financial investment; and to encourage discussion about the important factors that need to be considered when trying to secure funding

Timing: 20 minutes

Structure: Groups of four from Part 1

Feedback: Groups to present outline design to workshop using flipchart

Consider an upgrade example that might be applicable to a supply system familiar to at least one member of the group. With reference to this upgrade, draft an investment planning proposal to the water supply finance strategy team. Consider:

- Who would be the first person you would contact to get the issues raised?
- What internal management procedure would you need to follow to ensure that ideas for new capital investment are heard?
- What typical challenges might be encountered?
- What evidence might be needed to support any case for increased capital expenditure?
- Would extra training or research be required?

Note: The facilitator may be able to suggest some example upgrades for Part 2.

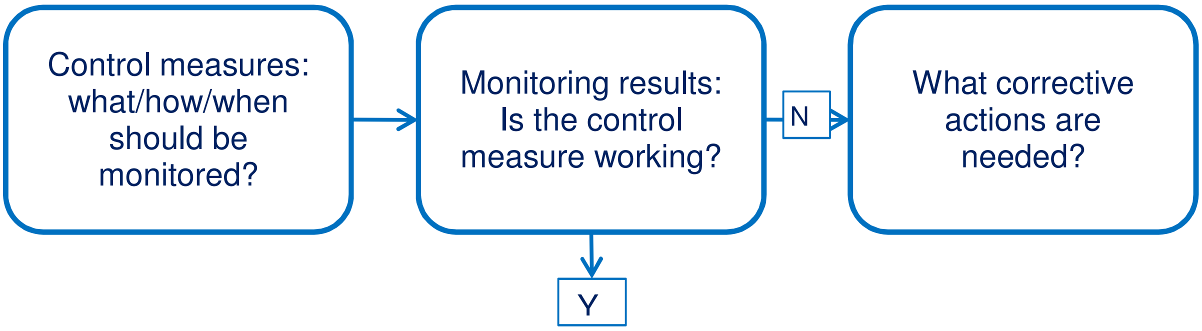
Module 6 – Define monitoring of the control measures

Learning objectives

Through active participation in and successful completion of Module 6, each participant should be able to meet the following learning objectives:

- Evaluate the importance of monitoring as a way of protecting the public's health.
- Develop a best-practice monitoring programme for their organization.
- Take the action required following any abnormal monitoring result.

Key points



- Definitions
    - Operational monitoring – the act of conducting a planned sequence of observations or measurements of control parameters to assess whether a control measure is operating within design specifications
    - Critical limit – a criterion that separates acceptability from unacceptability
    - Corrective action – any action to be taken when critical limits are exceeded
- The purpose of operational monitoring is to demonstrate that control measures continue to work.
- The monitoring results should tell you whether the controls are working or not.
- Operational monitoring should include corrective actions, which are the actions that should be taken when the results of monitoring show that the critical limit is exceeded.
- Procedures need to be in place on how to monitor these control measures, including information related to critical limits and corrective actions.
- Monitoring programmes need to include what, how, when, where and who.
- Persons responsible for monitoring, analysing and receiving results need to be identified.
- The person receiving the results needs to have sufficient power to enable immediate action to take place if the results exceed critical limits.
- Operational monitoring may already be ingrained within a utility's working practice. WSPs may highlight areas where monitoring is not needed, as well as areas where more is needed.
- Monitoring itself is not enough; operators need to understand the importance of their role so that tragedies such as Walkerton can be avoided in the future. Monitoring and corrective actions form the control loop to ensure that unsafe drinking-water will not be consumed.

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What factors besides "*what* to monitor" need to be considered during any effective monitoring programme?

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What challenges (in addition to the list below) exist that may have an impact on the effectiveness of monitoring of control measures? (Work in pairs and record on flipchart – 3 minutes)

- Absent or ineffective evaluation of data
- Staff expectations/attitude
- Lack of resources
- Availability of resources for corrective action
- ____
- ____
- ____
- ____
- ____
- ____
- ____
- ____

Swap your challenges with another pair before completing the next activity.

What actions may be suitable to mitigate the challenges listed? (Work in pairs and record on flipchart – 3 minutes)

Challenges	Action to mitigate

The Module 6 outputs are the accurate assessment of the performance of control measures at appropriate time intervals and establishment of corrective actions for deviations that may occur.

Exercise – Module 6

Aim: To emphasize the ease with which a tragedy can unfold, and to assess the steps that are necessary to mitigate such events

Timing: 45 minutes

Structure: Original groups of four

Feedback: Groups to provide outline answers on flipchart, to be reviewed by another group and fed back to workshop

Review the Walkerton water tragedy case-study provided (Appendix A) and highlight what went wrong in respect to the monitoring of control measures.

- Prepare a timeline of events and indicate the opportunities for intervention that could have prevented or reduced the scope of the outbreak.
- What actions should the operators of this facility have taken that could have prevented this outbreak?
- Who was to "blame"?

Module 7 – Verify the effectiveness of the WSP

Learning objectives

Through active participation in and successful completion of Module 7, each participant should be able to meet the following learning objectives:

- Understand the purpose of verification and describe the three key actions of verification.
- Understand the difference between operational monitoring and compliance monitoring and between validation and verification.
- Design an effective programme for verifying a WSP.

Key points

- Definitions:
    - Verification – the application of methods, procedures, tests and other evaluations to determine compliance with a WSP. Verification confirms that the water quality targets are being met and maintained and that the system as a whole is operating safely and the WSP is functioning effectively. It is made up of three activities:
        1. Compliance monitoring – for example, the use of *E. coli* measurements. Does the water quality meet the set targets?
        2. Internal and/or external auditing – to assess the practical implementation of WSPs and compliance. Auditors need a detailed knowledge of the system to be able to identify any possible fraudulent data, often needing to witness procedures in person.
        3. Consumer satisfaction – are users happy with the service and trust that the water is safe?
    - Validation – investigative activity to identify the effectiveness of control measures. It obtains the evidence that elements of the WSP can effectively meet the water quality targets.
    - Operational monitoring – the act of conducting a planned sequence of observations or measurements of control parameters to assess whether a control measure is operating within design specifications
- Verification is necessary to ensure that a WSP is working, that it is used in practice and that the water quality meets the set targets.
- External auditing is increasingly becoming a regulatory requirement for utilities. Where it is not a regulatory requirement, external auditing for the purpose of accreditation is increasingly being requested and is encouraged to support continuous improvement of the WSP.
- Auditing can highlight weak areas in operation and signpost where further investment (e.g. training) is needed.
- Key challenges to verifying a WSP include lack of capable auditors, lack of qualified laboratories, lack of resources, no consumer feedback and inaccurate documentation.

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What does an auditor need to know in order to effectively assess a WSP? (10 minutes)

Discuss experiences of when you have encountered incorrect and/or missing data. Why were the data incorrect? What were the implications? What might have been the implications?

The Module 7 outputs are confirmation that the WSP works and is used in practice and that the water quality meets the required standards.

Exercise – Module 7

Part 1 – Aim: To consider all elements involved in the development of a verification programme

Timing: 10 minutes

Structure: Two large groups

Feedback: Groups to provide verbal feedback to workshop

Group 1 – Consider what should be audited during verification

Group 2 – Devise a checklist of factors to consider when establishing a verification programme

What should be audited?	Verification programme checklist
e.g. water quality compliance	e.g. frequency and duration of verification

Part 2 – Aim: To consider all elements involved in the development of a verification programme

Timing: 20 minutes

Structure: Groups of four

Feedback: Groups to provide verbal feedback to workshop – focusing on challenges encountered and any additional factors worth consideration

Using the agreed audit and verification factors (from Part 1) as a starting point, develop an outline verification programme in the context of a supply system known to at least one group member.

Module 8 – Prepare management procedures

Learning objectives

Through active participation in and successful completion of Module 8, each participant should be able to meet the following learning objectives:

- Explain management procedures during different operating conditions.
- Emphasize the importance of organizational culture and management style when reporting near-misses.
- Design management procedure components for a given case-study supply system.

Key points

- Definitions:
  - Management procedures:
    - Standard operating procedures define the actions to be taken during normal operational conditions and should detail the steps to follow in specific "incident" situations (corrective actions) where loss of control of the system may occur.
    - Emergency management procedures to be followed during unforeseen (emergency) situations should also be documented.
- The procedures are written by experienced staff and updated as necessary.
- Near-misses as well as actual incidents should be recorded.
- The outputs of preparing management procedures include:
  1. Standard operating procedures:
     - Procedures during normal operation, principally operational monitoring with defined responsibilities
     - Procedures for corrective actions following incidents, including defined responsibilities and location of any needed backup equipment
  2. Emergency management procedures, which include responsibilities and alternative water supplies
  3. Communication protocols with consumers, the water supplier, health authorities, regulator and environmental agencies during normal and incident conditions
  4. Documentation – a programme to review and revise documentation regularly and following incidents, emergencies and near-misses

List the standard operating procedures for 1) facility operations, 2) disinfection, 3) surface source water abstraction and 4) groundwater abstraction, or any other four categories.

Create a corrective action procedure checklist

Standard operating procedures	Corrective action procedures – checklist
1)____	e.g. Location of backup power equipment
____	____
____	____
2)____	____
____	____
____	____
3)____	____
____	____
____	____
4)____	____
____	____
____	____

What organizational factors (e.g. management style) would best promote an environment where near-misses are reported and learnt from? How might this be cultivated within your utility?

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The Module 8 outputs are the preparation of management procedures, including advice on communication, corrective actions, standard operating procedures, emergency procedures and documentation.

Exercise – Module 8

Aim: To consider how to design management procedures

Timing: 25 minutes

Structure: Groups of four

Feedback: Groups to provide feedback to workshop using flipchart

Using the Walkerton case material, draft a document of management procedures that address the following points:

1. What water quality parameters and control measures should have been monitored as standard to support the supply of safe water?
2. What should the response actions have been when the analysed water samples showed microbial contamination and when the chlorine residual measurements were <0.5 mg/l?
3. Explain what communication protocols should have been in place, and identify who needed to be contacted, about what and when.
4. Identify who should have been responsible for coordinating emergency measures, including the provision of emergency water, the boil water advisory and the re-establishment of safe drinking-water.

Note: Only certain components of management procedures are covered in the given example.

Module 9 – Develop supporting programmes

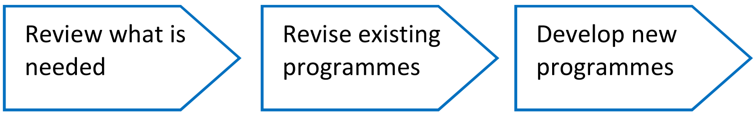
Learning objectives

Through active participation in and successful completion of Module 9, each participant should be able to meet the following learning objectives:

- Assess the relative importance of supporting programmes in the wider context of WSPs and the delivery of safe drinking-water.
- Explain what constitutes effective supporting programmes.
- Examine the role that organizational culture has on WSP implementation success.

Key points

- Definitions:
  - Supporting programmes – actions that are important in ensuring drinking-water safety but do not directly affect drinking-water quality (e.g. training and management practices)
- Supporting programmes are activities that support the:
  - Development of people’s skills and knowledge
  - Commitment to the WSP approach
  - Capacity to manage systems to deliver safe water.
- Supporting programmes are designed to “help you do a good job”, and they can range from research and development and individual training through to upgrading of equipment and operating hygienically.
- Supporting programmes can make the difference between WSP success or failure, as often the sustainability depends not on following the step-by-step approach, but on developing the right support for people in roles of responsibility.
- A very important supporting programme deals with the cultivation of a WSP organizational culture.
- Success factors:
  - WSPs are not just a step-by-step process guaranteeing safe water.
  - Personal accountability and responsibility are essential components.
  - Broader stakeholder engagement is vital.
  - Organizational commitment is fundamental.
- When developing supporting programmes:



- Resourcing is a major challenge. Supporting programmes can be considered by some as non-essential or of lesser importance.
- Another major challenge is to cultivate a culture of fair blame, with avenues to encourage open communication, so that near-misses or incidents are reported and actively learnt from.

Discuss real or theoretical examples where having support (e.g. training) could directly lead to improved water safety.

What supporting programmes are you aware of at your utility?

The Module 9 outputs are the development of activities that ensure that the WSP approach is embedded in the water utility’s operation.

Exercise – Module 9

Aim: To evaluate the way in which organizational culture can present itself, and to consider its impact on WSP implementation

Timing: 25 minutes

Structure: Groups of four

Feedback: Groups to provide verbal feedback to workshop

Review the five quotations provided. These are taken from various case-studies conducted with water utilities trying to implement WSPs.

- What assumptions can be made from each quotation?
- Are they positive or negative?
- Of those that are negative
    - How might this hinder WSP development?
    - How might this be overcome?
- Of those that are positive
    - How might this aid WSP implementation?
    - How could this enthusiasm be harnessed?

All the workshop quotations are available in Appendix B, where you can also write the answers.

Module 10 – Plan and carry out periodic review of the WSP

Learning objectives

Through active participation in and successful completion of Module 10, each participant should be able to meet the following learning objectives:

- Explain when and what to review in the WSP.
- Mitigate against some common challenges in reviewing the WSP.
- Explain clearly the benefits of an up-to-date WSP.

Key points

- The WSP team should reconvene at agreed periods to review the WSP.
- The team can learn from:
  - Near-misses
  - Training
  - Regular monitoring
  - New procedures.
- A continually updated WSP gives confidence to operational staff and external stakeholders that the best possible activities are in place to protect the public's health.
- The review should include updating for new risks – although this should also be done immediately after a new risk is identified. The periodic review is a way of ensuring that it has been done.
- It is important to review all aspects of the WSP and amend as necessary. This includes accounting for the following: changes in the water supply system, improvement programmes, revised procedures, staff changes and stakeholder contact details.
- The main challenges are:
  - Reconvening the WSP team (person availability)
  - Retaining institutional memory when staff change
  - Maintaining enthusiasm and ensuring continual support after the WSP is implemented
  - Keeping in touch with stakeholders
  - Keeping up-to-date records.

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1) When do you review a WSP?

2) What do you review/ensure is up to date?

3) What are the main challenges in reviewing?

4) What are the main benefits?

The Module 10 outputs are an up-to-date WSP is that appropriate for the given context.

Exercise – Module 10

Part 1 – Aim: To be aware of the main factors that need to be considered when conducting a WSP review

Timing: 10 minutes

Structure: Individually

Feedback: Verbal feedback to workshop

Call out to the facilitator what agenda items there might be at a WSP review meeting and how often the meeting should take place.

Example agenda items

- e.g. Last meeting's review & minutes
- ____
- ____
- ____
- ____
- ____
- ____
- ____

Part 2 – Aim: To review and question material from Modules 1–10

Timing: 20 minutes

Structure: Groups of four

Feedback: Questions and answers

Review the case-study material provided. Highlight any areas of uncertainty. Write a question (at least one question per person) relating to that case-study *or* module and post it in the question box.

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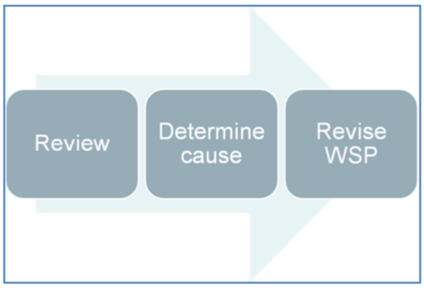
Module 11 – Revise the WSP following an incident

Learning objectives

Through active participation in and successful completion of Module 11, each participant should be able to meet the following learning objectives:

- Identify in what circumstances and for what benefit a WSP review is needed (identify why a WSP review is needed following emergencies, incidents and near-misses).
- Explain the need for a fair blame culture.
- Evaluate how a WSP might be modified following a given incident, emergency or near-miss.

Key points



- After an incident or near-miss, the WSP must be reviewed. The cause of the incident should be determined and then revisions to the WSP made.
- The WSP should be reviewed after an incident, emergency or near-miss, regardless of whether a new hazard/hazardous event was identified.
- Reviewing the WSP should reduce the likelihood of the incident being repeated and determine whether the actual response was the best possible.
- After an incident, it can be difficult to establish what the chain of events was, and who was responsible.
- The main benefit of reviewing the WSP after an incident is better protection of the public's health, i.e. you must learn from the incident, not just record it.

From your direct or indirect experience, discuss:

1. When blame happened.
2. Why can blame be bad?
3. Why can blame be good?

1)____

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2) ____

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3)____

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The Module 11 outputs are:

- A comprehensive and transparent review of why the incident occurred and the adequacy of the utility's response
- Incorporation of the lessons learnt into WSP documentation and procedures.

Exercise – Module 11

Aim: To evaluate an incident (*Cryptosporidium* outbreak) and review the existing excerpts from a WSP in order to reduce the likelihood of a recurrence

Timing: 30 minutes

Structure: Groups of four

Feedback: Rotate tables and review another groups WSP; verbal feedback to workshop

Evaluate the reported incident and existing WSP. Modify the WSP to reduce the risk of the incident recurring. Consider what future investments and additional treatment or changes to treatment might be needed.

Case-study: There has been a *Cryptosporidium* outbreak in the local community that was attributable to contamination of the drinking-water supply. The source is a river abstraction that goes straight to treatment with no raw water storage. Treatment includes coagulation, clarification, sand filtration and chlorine disinfection. The filter backwash is recycled to the head of the works.

Following investigation of the incident, poorly maintained septic tanks were found in the catchment, as well as farm animals gaining access to the river. There are a number of licensed discharges from sewage works several kilometres upstream of the intake that are operated by another organization. Prior to the incident, there had been a period of heavy rain.

A simplified version of the catchment and treatment sections of the (flawed) WSP is provided (Table 11.1), which was produced before the outbreak occurred (note: not all the details are included). The WSP uses a standard 5 × 5 risk scoring matrix.

Table 11.1 – Flawed WSP excerpts for catchment and treatment (pre-*Cryptosporidium* incident)

Note there are possible improvements that can be made.

Hazardous events	Explanation	Controls	Monitoring	Risk			Improvement plan	Exercise aid
				L	C	S		
Contamination from septic tanks within the catchment	Several properties that do not have mains sewage have been identified within a kilometre of the WTW intake.	Septic tank licensing rules by local government that specify distance from water courses and depth; plus cleaning schedules.	Monitoring of treated water for indicator organisms (*E. coli*).	2	4	8	No direct control over catchment, so no improvements possible.	Rules are in place, but the government department is unable to police adherence to the rules over time. Is the water company really powerless in the catchment?
Untreated discharge from sewage works upstream of intake	Sewage works is operated by another organization; in times of heavy loading, may overflow into river.	Sewage works is subject to regulations and has licensed discharges.	Agreement was set up 5 years ago with sewage operator to notify WTW if overflow occurs.	2	5	10	No improvement needed because of agreement.	The water supplier still had not confirmed that the sewage works follows the agreement and assumes that it will be notified if necessary.
Failure of coagulation	Failure of coagulation stage leading to ineffective filtration stage, production of disinfection by-products at later stages.	Routine maintenance schedules; shut down works; backup coagulant pumps.	Online monitoring of turbidity.	1	4	4	Review maintenance schedules.	
Failure of disinfection	Failure of disinfection stage leading to bacteriological breakthrough. Pumps have failed in past, but automatic switch to backup.	Alarms when chlorine drops; backup chlorine pumps; shut down works.	Online monitoring of chlorine.	3	4	12	Pumps are old, request new equipment.	

L = likelihood, C = consequence, S = score, WTW = water treatment works

Table 11.1 (continued) – Flawed WSP excerpt for catchment and treatment (pre-*Cryptosporidium* incident)

Hazardous events	Explanation	Controls	Monitoring	Risk			Improvement plan	Exercise aid
				L	C	S		
Failure of filtration	Failure of filtration stage leading to ineffective organic removal and production of disinfection by-products.	Routine maintenance and cleaning schedules; shut down works; backup filters.	Online monitoring of turbidity.	1	4	4	Review maintenance schedules.	
Cryptosporidium entering WTW	Unlikely – see catchment section. Not had a problem with this in the past.	Coagulation and filtration suitable for low-risk situations.	Monthly raw water monitoring.	1	4	4	N/A	Are they right to consider this as a low-risk area?
Faecal contamination from farm animals within the catchment entering WTW	Dairy and sheep farming upstream. However, livestock are fenced off at least 1 m from the water course.	Fencing off of livestock from water course.	Annual visual inspection of the catchment by WTW operators.	2	4	8	No direct control over catchment, so no improvements possible.	Since the last visual inspection, animals have breached the fence. Farmer is unaware of this and also unaware of the potential consequences.
Faecal contamination entering WTW	Unlikely to occur – see catchment section. Regulations are in place regarding septic tanks/sewage works and farms. However, there is no raw water storage.	Treatment to remove microbial pathogens if the event did happen; chlorine disinfection.	Monthly raw water monitoring.	1	4	4	N/A	Are they right to consider this as a low-risk area?

L = likelihood, C= consequence, S = score, WTW = water treatment works

WSP quality assurance tool (Module 12)

Learning objectives

Through active participation in and successful completion of Module 12, each participant should be able to meet the following learning objectives:

- Explain why WSP benefits are realized only through sustained effort and continuous improvement.
- Evaluate the benefits that use of the WSP quality assurance (QA) tool can bring, who can use the tool and when it can be used.
- Demonstrate an ability to use the tool to support and assess WSP implementation.

Key points

- The WSP quality assurance tool is an Excel-based tool that enables systematic evaluations of WSP development and implementation. Use of the tool will help to identify areas for improvement, thereby facilitating WSP implementation efforts.
- The tool can be used at all stages of WSP development and implementation to compare systems and to track progress over time.
- The tool will not identify what actions should be taken, only where improvement is needed.
- The tool is divided into four sections: 1. Main menu page, 2. Introduction page, 3. Assessment page and 4. Assessment results page.
- To fully understand each question in the assessment section, the scoring definitions as well as the information included in the guidance section should be read. Often the accompanying guidance note will contain further details that should be considered in assessment against a WSP step.
- For self-assessment purposes, it is important for the entire WSP team to contribute to the assessment process for accurate interpretation of questions and scores.
- It is important not to place too much emphasis on the exact scores obtained. The purpose of the scoring process is to help identify where improvements should be targeted.
- It is important to use the comments/rationale field to:
    - justify why a particular score was given
    - explain the users' interpretation of a question if unsure of terminology used or meaning of question
    - explain why a question was not answered
    - document evidence for a particular answer.
- When creating a new question, two types of question can be added, an assessment type that is added to the cumulative score and a non-assessment type. The user can use the comments field to insert guidance and references. This space should also be used to include definitions for the 0–4 grading scale if an assessment-type question has been selected. The text of new questions will be listed in a different coloured font to distinguish them from standard questions.
- New assessments can be added to enable assessment of WSP progress over time and to compare WSP performance between different water supply systems.
- Summary tables and graphs can be generated in the assessment results page. These summaries are useful when communicating WSP progress with senior management and when trying to justify the additional resources needed to improve the WSP process. Results can be exported into a different Excel file, MS Word and PowerPoint.

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What additional benefits could using the tool bring?

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Exercise – Module 12

Aim: To familiarize yourself with the WSP QA tool, be able to navigate and populate the tool and be aware of its benefits and potential outputs

Timing: 50 minutes

Structure: Pairs

Feedback: Facilitators to provide feedback during exercise

- Open the tool and enable macros.
- Complete the assessment for your water utility – if the answers are not known, please estimate (this exercise is not intended to assess your utility but to familiarize yourself with the tool for when you do come to use it in the future). You may not yet have started, or may be in the early stages of, WSP development, but the tool can still be used as a starting point, and certain elements of the WSP may already be in place (e.g. the supply system may already be documented). If you are unable to complete the assessment using details from your utility, please see the assessor for a fictional example.
- Create a new “assessment”-style question that is relevant to your utility (in any table between 3 and 12).
- What references are suggested for question 3.1? (hint: ensure that “show guidance” is checked).
- How was 4.1 assessed? Did you consider the below points in your assessment (hint: ensure that the guidance information as well as the definition for a score of 4 has been fully reviewed)?
    - Does the system description include all the sources, abstraction points, treatment sites, treatment streams, service reservoirs, pumping stations, area of supply and connections to other water supply systems?
    - Is the flow diagram / system schematic sufficiently detailed to identify where the system is vulnerable to hazards and where existing controls are sited?
    - Is there information regarding the users and uses of the water?
    - Is there information on the water quality targets?
    - Is the flow diagram / system schematic dated?
- Enter the following information:
    - 5.1a = 4; 5.1b = 0; 5.1c = 1; and 5.1d = 2
    - 5.2a = 1; 5.2b = 0; 5.2c = 0; and 5.2d = 4
    - Why is the assessment cell for question 5.2b dark grey?
    - Why is the assessment cell for question 5.2d red?
- View summary tables for general information results.
- Export summary graphs for WSP steps into MS Word and save to the desktop.

Competence wheel exercise (Part II)

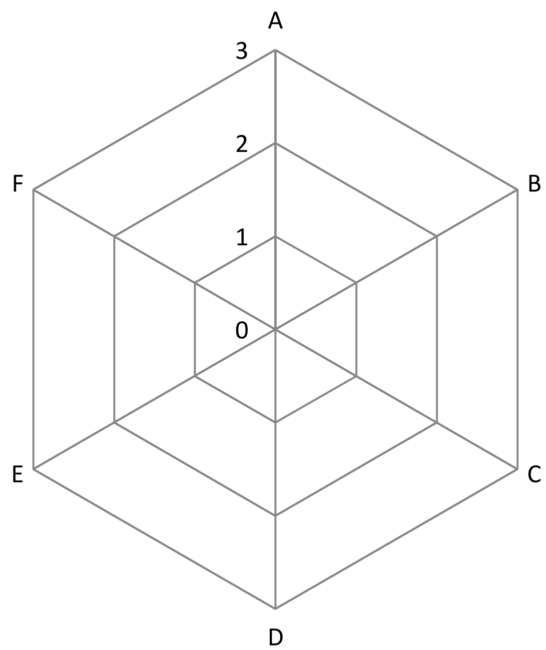
Score your agreement with the following six statements (A–F). This is for your own use only.

A. I have a thorough understanding of what is involved in WSP design and implementation.
B. I know where most of the hazards are in the water supply system where I work.
C. I have a thorough understanding of the complexities of risk assessment and know of the two main approaches.
D. I know how a WSP is used to steer financial investments within the water utility where I work.
E. I know what a control measure is and how it is used, monitored and validated.
F. I know when a WSP should be reviewed and amended.

For each question, assign a score between 0 and 3:

0 = No understanding and/or not heard of
1 = Little understanding and/or could not apply in practice
2 = Good understanding and/or could apply in practice
3 = Complete understanding and/or have applied in practice and/or could train others

Enter your scores on the wheel diagram below. Compare your scores with those completed on Day 1.



Essential resources

Bartram J et al. (2009). *Water safety plan manual: step-by-step risk management for drinking-water suppliers*. Geneva, World Health Organization.
http://www.wsportal.org/wspmanual
http://www.who.int/water_sanitation_health/publication_9789241562638/en/index.html

Helmer R, Hespanhol I, eds (1997). *Water pollution control—a guide to the use of water quality management principles.* London, E & FN Spon. Published on behalf of the United Nations Environment Programme, Water Supply and Sanitation Collaborative Council and World Health Organization. http://www.who.int/water_sanitation_health/resourcesquality/wpcbegin.pdf

Water Safety Portal
http://www.wsportal.org

WHO (2011). *Guidelines for drinking-water quality*, 4th ed. Geneva, World Health Organization.
http://www.who.int/water_sanitation_health/dwq/guidelines/en/index.html

WHO (2012). Water safety plan quality assurance tool v1.3 (Excel tool and manual)
http://www.wsportal.org/templates/ld_templates/layout_1367.aspx?ObjectId=20686&lang=eng
http://www.who.int/water_sanitation_health/publications/wsp_qa_tool/en/index.html

WHO Lexicon
http://apps.who.int/thelexicon/entry.php

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Appendix A

Walkerton water tragedy – Module 6 exercise

- Walkerton (population 5000), Ontario, Canada.
- Incident: Breakthrough of *E. coli* O157:H7 and *Campylobacter* bacteria into drinking-water supply.
- Outcomes: 7 deaths, 2300 cases of illness (27 with potentially lifelong implications); hundreds of millions of dollars in compensation and investigation expenses. Two people jailed.

In 2000, Walkerton's water supply came from three wells, named Well 5, Well 6 and Well 7 (Table A). Typically, Well 7 was used, as this had the capacity to serve the entire town and was a deeper well than either Well 6 or Well 5.

Table A – Description of Wells 5, 6 and 7 – Walkerton, 2000

Well	Location	Depth (m)	Casing depth (m)	Overburden depth (m)	Water supply	Capacity (Ml/d)
5	Edge of town near farmland	15	5	2.5	water supply zones from 5.5 – 7.4 m depth	1.8
6	3 km west of town	72	12.2	6.1	50% from ~19 m depth	1.5
7	~3.5 km west/northwest of town	76.2	13.7	6.1	100% from below 42 m, 50% from ~70 m depth	4.4 (120% of town's needs)

Studies revealed that there was a hydraulic pathway linking Wells 6 and 7. Both were disinfected by gas chlorination. Well 5 was disinfected by hypochlorite solution.

From 8 to 12 May, Walkerton experienced about 134 mm of rainfall (1 in 60 year event), with 70 mm falling on 12 May. The result of the heavy rainfall was flooding in the Walkerton area. Flooding was seen near Well 5 on the evening of 12 May.

The General Manager (GM) of Walkerton Public Utilities (PUC) was away from 5 to 14 May. The Foreman was therefore responsible for the operation of the water supply at this time. On 3 May, the chlorinator for Well 7 broke down, and for 6 days, the town received unchlorinated water from Well 7, which was against the provincial treatment requirements. The chlorinator on Well 7 was not replaced until 19 May. From 9 to 15 May, the water supply for the town was switched to Wells 5 and 6, with Well 5 as the primary source.

On 13 May, according to the daily operating sheets, the Foreman performed checks on pumping flow rates and chlorine usage and measured the chlorine residual in the water entering the distribution system. He recorded a daily chlorine residual measurement of 0.75 mg/l for treated water from Well 5 on 13 May and again for 14 and 15 May. A subsequent inquiry concluded that these operating sheet entries were fictitious.

On 15 May, the GM returned and turned on Well 7, despite the chlorinator still being broken. Well 7 supplied the town until 20 May. Well 5 was shut off at 1:15 pm on 15 May, making the unchlorinated Well 7 supply the only source of water for Walkerton during the week of 15 May.

Samples were typically submitted once per week. On 1 May, the sample volumes were too small for analysis, and there was a labelling discrepancy. On 8 May, no samples were submitted. Raw and treated water samples were taken on 15 May from Well 7, the distribution system and a mains construction site on Highway 9. The four samples were sent for analysis, but were submitted incorrectly.

On 17 May, the laboratory called the water utility and faxed the GM to inform him of the presence of *E. coli* in the highway and distribution samples. The Walkerton ones “didn’t look good either”.

The tests conducted on three of the four samples submitted (not Well 7 treated) indicated only a presence or absence of indicator bacteria. Only the sample labelled “Well 7 treated” was analysed to enable a bacterial count to be determined. However, in this case, the sample was so contaminated that it produced an overgrown plate with bacterial colonies too numerous to count. The subsequent inquiry concluded that this sample was most likely mislabelled and was more likely representative of the water from Well 5. The laboratory did not fax the results to the Ministry of the Environment (MOE) or Ministry of Health (MOH) as was “expected” (note, not required). The GM advised the consultant for the Highway 9 project that their samples had failed so they would need to rechlorinate, flush and resample to complete the project.

On Thursday, 18 May, the first signs of illness were becoming evident in the health-care system. Two children were admitted to the hospital in Owen Sound, 65 km from Walkerton, both with bloody diarrhoea. The attending paediatrician noted that both children were from Walkerton. Bloody diarrhoea is a notable symptom for serious gastrointestinal infection, particularly infection with *E. coli* O157:H7. Accordingly, the paediatrician submitted stool samples from these children to evaluate that diagnosis.

By Friday, 19 May, the outbreak was evident at many levels. Thirty-three children were now absent from Walkerton schools with stomach pain, diarrhoea and nausea. Several residents of retirement homes and long-term care facilities also developed diarrhoea. A Walkerton physician had examined 12 or 13 patients suffering from diarrhoea.

The hospital paediatrician in Owen Sound notified the responsible public health agency for Walkerton (based in Owen Sound) of the emerging problems on 19 May. A Walkerton school administrator also called the public health inspector at the Walkerton office of the Health Unit to report the number of children absent and stated that she suspected the town’s water supply was the source of the problem.

In contrast, the Health Unit officials suspected a foodborne basis for the outbreak, by far the most common cause of such diseases. Nonetheless, the Health Unit called the GM in the early afternoon of 19 May. By the time he called, the chlorinator had been installed on Well 7, so that it was supplying chlorinated water to Walkerton’s distribution system. The GM advised him that “everything’s okay”, despite having been faxed the adverse microbial results from the Highway 9 project, the distribution system *and* the sample labelled Well 7 treated two days earlier.

Later that afternoon (19 May), an administrator of the Health Unit based in Owen Sound also called the GM asking whether anything unusual had happened in the water system. The GM mentioned that there was a water mains construction under way, but made no mention of the adverse bacteriological results or of operating Well 7 from 3 to 9 May and from 15 to 19 May without a chlorinator.

The reassurances about the water’s safety from PUC’s GM kept the Health Unit staff pursuing a foodborne cause for the outbreak. Meanwhile, the GM increased the chlorination level at Well 7 and began to flush the distribution system until 22 May.

By Saturday, 20 May, the outbreak was straining the Walkerton hospital, with more than 120 calls from concerned residents, more than half of whom complained of bloody diarrhoea. After the Owen Sound hospital determined that a stool sample was presumptive positive for *E. coli* O157:H7, the Health Unit notified other hospitals in the region.

On Saturday, the Health Unit contacted the PUC GM again to determine the current chlorine residual levels in the water and to receive reassurance that the water system would be monitored over the weekend. The GM assured the Health Unit that there were measurable levels of chlorine residual in the distribution system, leading health officials to believe that the water system was secure.

Early on Saturday afternoon, the Health Unit (Owen Sound) contacted the local Medical Officer of Health, who had been out of town during the onset of the outbreak, to advise him of the emerging outbreak. By that time, several people in Walkerton were reporting bloody diarrhoea, and 10 stool samples had been submitted for pathogen confirmation.

A concerned PUC employee began to suspect something was wrong with Walkerton's water. He had learnt that the samples from the Highway 9 project had failed testing and phoned the MOE (Ontario) anonymously to report his concerns and provide a contact number at PUC for the MOE to call about the Walkerton water system. In the early afternoon of Saturday, 20 May, a MOE employee who received the anonymous call phoned the GM to find out if there were problems with the system. The MOE employee was reassured that any problems with bacteriological results had been limited to the Highway 9 mains replacement project some weeks earlier. Later that evening, the concerned PUC employee followed up his call with the MOE, and eventually the MOE agreed to contact the local MOE office (in Owen Sound) to look into the matter further.

The outbreak continued to expand. By Sunday, 21 May, there were more than 140 calls to the Walkerton hospital, and two more patients were admitted to the Owen Sound hospital. A local radio station interviewed the local Medical Officer of Health on Sunday morning and subsequently reported on the noon news that drinking-water contamination was an unlikely source of this outbreak, but with little else to go on, a boil water advisory was issued at 1:30 pm. This notice was provided only to the local AM and FM radio stations; additional publicity by the television station or by direct door-to-door notification was not pursued.

The Health Unit established a strategic outbreak team to deal with the emergency. Local public institutions were to be notified about the boil water advisory. By that evening (21 May), the Health Unit had notified provincial health officials of the outbreak and requested the assistance of major hospitals in London and Toronto in treating Walkerton residents and the assistance of Health Canada in conducting an epidemiological investigation.

By Monday, 22 May, the Health Unit had received reports of 90–100 cases of *E. coli* infection, and the first victim died. The regional MOE official in Owen Sound had been notified the previous evening about the outbreak but did not initiate a MOE investigation, even after being advised about the large number of cases of *E. coli* infection and that the Health Unit suspected the Walkerton water system. Only after being contacted later that day by the local Medical Officer, who stressed the urgency of the situation, did the regional MOE initiate an investigation by sending an environmental officer to Walkerton to meet first with the Health Unit and then with PUC's GM. The environmental officer was asked to obtain any microbiological test results from PUC for the previous two weeks. The GM did not tell the officer about the adverse bacteriological results for 15 May, but did provide him with a number of documents, including the 17 May laboratory report. When the officer reviewed the report, he did not report the alarming evidence of water contamination to his supervisor, because he believed that the boil water advisory had eliminated any urgency.

In the meantime, the Health Unit was continuing its research, suggesting that the most likely date of contamination was between 12 and 14 May and revealing that cases were distributed across the area served by the Walkerton water distribution system. By that evening, the Health Unit was convinced this was a waterborne outbreak, even though it had not yet been provided with the adverse results for 15 May.

On Tuesday, 23 May, the second victim died. The Health Unit also received bacteriological results from water samples it had taken around Walkerton which had evidence of coliforms. When the Health Unit presented these to the GM, he finally admitted to the adverse water quality results from 15 May (reported on 17 May).

Ultimately, 5 more deaths, 27 cases (median age of 4) of haemolytic-uraemic syndrome, a life-threatening kidney condition that may subsequently require kidney transplantation, and 2300 cases of gastrointestinal illness were attributed to the consumption of Walkerton water. The Ontario Clean Water Agency took over operation of Walkerton's water system. The boil water advisory was lifted on 5 December.

Note: As illness emerged in the community, the GM and Foreman of PUC remained convinced that water was not to blame, and they continued to drink the water. In the past, they had often consumed Well 5 water before chlorination, because they did not recognize the danger of pathogen contamination.

This case-study and exercise were adapted from Hrudey SE (2006) *Fatal disease outbreak from contaminated drinking water in Walkerton, Canada.* Association of Environmental Engineering & Science Professors (AEESP Case Studies Compilation 2006; http://www.aeespfoundation.org/publications/pdf/AEESP_CS_1.pdf).

Appendix B

Quotations for Module 9 exercise

"Top management is OK, as long as it doesn't interrupt whatever the operations people are doing. Whatever they are doing now is quite OK with regards to water quality, we don't have a high number of violations or anything so to have WSP is OK as long as it doesn't give too much burden at the end of the day, to the people who are doing the work." **Water quality manager**	
"Basically one of the obstacles that we face is people. I don't want to name names, but when we do new things like WSP, it's like crossing borders." **WSP team member**	
"When it comes to implementing initiatives like this, some of the people are actually quite challenging and some of these people can be at top management level." **WSP team member**	
"I have some idea of the WSP, I have been to some of the talks but I'm not sure what the actual objective is, because to me we have been doing it already, so I'm not sure what is the expected outcome of the WSP." **Water treatment works manager**	
"Here we have no control over the catchment, it is being taken care of by another authority. We only take care from the intake up to the customer, so how can we do a catchment to consumer WSP?" **Water treatment works manager**	
"Well the challenge in implementing any programme in this company, which we have a few like six sigma, ISO, lots of things, lots of different departments so I think with trying to implement another programme, you come up against objections." **Source unknown**	

"Yes, but not in detail. It's more in the quality department. We haven't been involved really at the moment, we are still in the early stage. We just have our own initiatives like I mentioned are our efforts to maintain water quality." **Water treatment works manager**	
"I was partially involved in the WSP but I can't remember the details. They didn't give us that much information at the time that I can remember. I really don't remember that much about it." **Water treatment works operator**	
"We got really busy all of a sudden and the WSP got forgotten, the frills of doing extra stuff…. It was purely a manpower issue." **CEO**	
"I'm not even sure we've really talked about a WSP but if someone had to give you a reason why we haven't implemented it, I think we would say, well what would we gain from doing that? I think department managers have got a good enough handle on what the risks are already." **Water quality manager**	
"I think the main problem is that all the members of the team have their routine work as well." **WSP team member**	
"You must aim for 100%, in water quality I believe that compliance must be 100%, it should be 100% because you cannot say that it's OK if one person in 1000 gets sick because of our water. Nobody should get sick." **CEO**	
"The thing about the water industry is you cannot rest, you rest and that is when you get into trouble, so it's about being on your toes all the time, what we provided yesterday is of no consequence tomorrow,	

we have to always constantly try.” **Executive manager**	
“Well we have our standard operating procedures, we have trained staff, very good monitoring, should something come up we have engineered backup systems in place.” **Source unknown**	
“I went to the conference and got all charged up. At the conference, it was the first time I had been exposed to WSPs and it looked like a really good idea.” **CEO**	
“But I think the most important is that people know the system, because sometimes you go to companies and people say OK, I work in this department, in this area and I just know what I do, I don’t care what the other people do. The WSPs involve all employees so it’s very important to create a team spirit.” **WSP team member**	
“It’s difficult sometimes because we would have discussions and people would say ‘oh we never had that’ (never experienced the event in the past). So it’s good that we have never had a major event, but it can happen, so we need to be sure that when it happens we have the appropriate barriers and know how to act.” **WSP team member**	
“We impose stricter guidelines on ourselves, because you would never want to go through that reporting process for a violation. That causes a lot of red tape, disciplinaries and fines etc.” **Water treatment works operator**	
“The standard has been changing over the years. What was normal say 25 years ago is substandard now. And quite frankly it’s a good thing! The more you improve it the smoother things run.” **Water quality**	

manager	
"We want to be the preferred water solution company in this country, number one in the country, recognized within the region." **WSP team member**	
"Our mission? We are looking at cost effectiveness, cost efficiency." **Water treatment works operator**	
"We don't like dry taps and one of the things we take very seriously here is connection hours. If we have a break then we shut down the areas that are immediately impacted but we'll reroute our system to make sure as many people are with water as possible. We minimize down time and do that extremely well." **CEO**	
"One of our drivers is to gain the confidence of the public, and probably so they can justify the bill, people want to know what they are getting for their money." **WSP team member**	
"It's cheaper to work with quality – there are several people that don't understand that and don't want to understand that." **WSP team member**	
"They (highly publicized water quality incidents) definitely changed the way we all worked. You know, we've gone to courses, we've gone to seminars. The knowledge is more there now, we've got to protect our water here, water is very precious." **Water treatment works operator**	