Water Safety Planning
for Small Community Water Supplies

Step-by-step risk management guidance for drinking-water supplies in small communities

World Health Organization

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Photographs on cover (from top to bottom, left to right): Water safety plan team members examining protected area around storage tanks supplying piped water to Shisuwa Badahare, Nepal; storage tank in Shisuwa Badahare, Nepal; tapstand in Kavre, Nepal; community meeting to discuss the water safety plan in Kavre, Nepal, August 2009

Excerpt summarized from Government of Nepal (2009):

The water safety plan team for the Kavre water supply analysed the system and identified all critical hazards with support from a water supply engineer. Improvements to the system that required little money were implemented immediately (e.g. installation of a control valve at the intake point, leakage repairs, raising of floor and washout pipe of reservoir tank). During a support visit, the operator expressed his satisfaction, noting that it was now very easy to monitor, operate and clean the system and, additionally, that it now seemed very safe too.

Contents

Preface

The principles and practice of water safety planning are increasingly being adopted around the world as the basis for the provision of safe and clean drinking-water. This process is most pronounced in urban conglomerates where the institutional infrastructure of municipal corporations, parastatal enterprises or private utilities is conducive to their adoption.

Water safety planning has a number of unique characteristics. One of these is its adaptability to different socioeconomic settings. Another is its capacity to be effectively applied at different levels and scales.

A considerable number of people in today's world have to rely on small community water supplies for their everyday basic needs, both in industrialized and in less developed countries. These communities, often in remote places, tend to lack capacities for essential management, operation and maintenance, and implementation of technical improvements.

Water safety plans provide a reliable framework for such communities to strengthen their capacities and capabilities with a focus on cost-effective management of their water supplies. The present guidance document puts water safety planning in the context of small community water supplies and provides a step-by-step approach for those charged with dealing with the everyday realities of maintaining a reliable, safe supply. It addresses members of small communities themselves, in addition to those supporting them in their endeavours to bring safe and clean water collectively to millions of people.

The International Small Community Water Supply Management Network, hosted by the World Health Organization (WHO), has made it its priority to provide tools, like this manual, that are of immediate practical use. The energy invested by the members of this Network needs due recognition. Both the WHO Water, Sanitation, Hygiene and Health programme and the Network look forward to feedback from the field on ways to further improve the manual, to be incorporated in the next edition of this text.

Robert Bos
Coordinator
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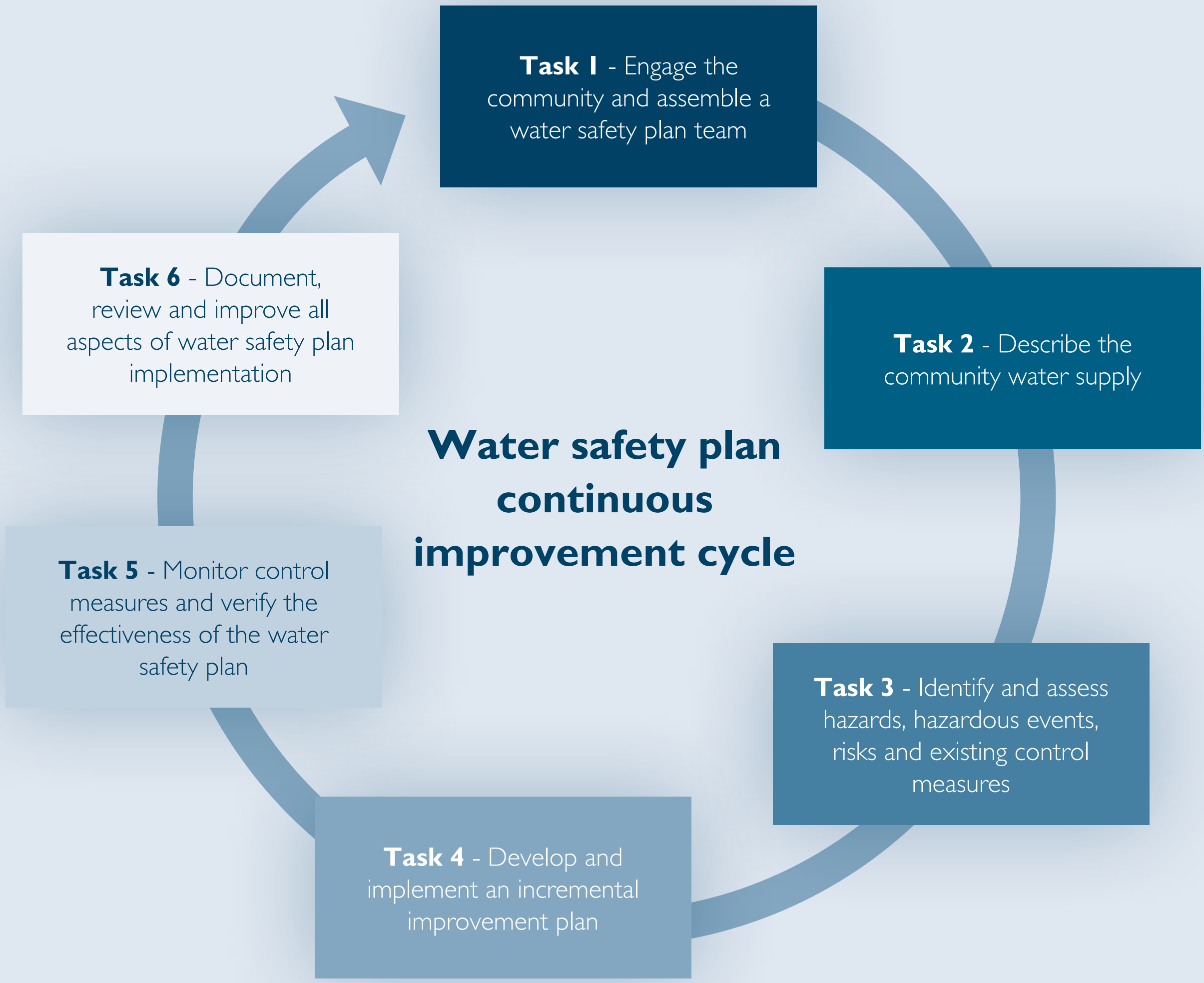
Geneva, Switzerland

The six tasks to develop and implement a water safety plan in small community water supplies



Water safety plan continuous improvement cycle

Task 1 - Engage the community and assemble a water safety plan team

Task 2 - Describe the community water supply

Task 3 - Identify and assess hazards, hazardous events, risks and existing control measures

Task 4 - Develop and implement an incremental improvement plan

Task 5 - Monitor control measures and verify the effectiveness of the water safety plan

Task 6 - Document, review and improve all aspects of water safety plan implementation

Introduction

Purpose of the manual

This manual is designed to engage, empower and guide communities in the development and implementation of water safety plans (WSPs) for their drinking-water systems. It provides guidance on how to apply effective and achievable management actions in order to improve the safety and quality of supplied water. Relevant to all community-managed systems, it is applicable to piped schemes, point sources such as hand pumps, protected springs or household rainwater harvesting systems and other sources. The guidance provided is valid for both new and existing schemes.

The manual is complemented by the World Health Organization's (WHO) *Guidelines for drinking-water quality* (WHO, 2011a), which describe the principles of the WSP approach, and the *Water safety plan manual: step-by-step risk management for drinking-water suppliers* (Bartram et al., 2009), a practical guide to developing WSPs for larger water supplies managed by a water utility or similar entity. Tools (e.g. sanitary inspection forms) included in Volume 3 of the WHO *Guidelines for drinking-water quality,* entitled *Surveillance and control of small community supplies* (WHO, 1997), will also be a useful resource for small community water supplies throughout the WSP development and implementation process.

Household-level water safety practices, such as point-of-use water treatment, safe storage and proper hygiene, are important additional interventions that can complement and be incorporated in the WSP approach, but are not the focus of this document. Additional information on household water treatment and safe storage can be found at http://www.who.int/household_water/en/.

Village health team members discussing hepatitis E prevention through use of a safe water chain in Akwach sub-county, Uganda, 2009

Overview of contents

The manual describes the rationale for WSPs by answering the following questions:

- What are small community water supplies, and why are they important?
- What is a WSP?
- Why should WSPs be applied in small community water supplies?

It then goes on to provide six step-by-step tasks describing how to develop and implement a WSP in a small community water supply:

- Task 1 – Engage the community and assemble a WSP team.
- Task 2 – Describe the community water supply.
- Task 3 – Identify and assess hazards, hazardous events, risks and existing control measures.
- Task 4 – Develop and implement an incremental improvement plan.
- Task 5 – Monitor control measures and verify the effectiveness of the WSP.
- Task 6 – Document, review and improve all aspects of WSP implementation.

Target audience

The manual is intended for use by development professionals working in and providing assistance to small communities, including:

- local government officials, especially health and drinking-water/sanitation officers;
- nongovernmental organizations (NGOs) supporting drinking-water supply activities;
- primary health-care staff working on improving water, sanitation and hygiene services;
- other interested community-based organizations and individuals.

This manual will also be useful for those with drinking-water and health-related responsibilities working at a national level to guide the development of policies and programmes to improve the management of small community water supplies. Finally, it will also be helpful to members of the small community water supply themselves, as water supply operators and caretakers will be key players in the WSP development and implementation process.

Key principles

The manual highlights a number of key water safety planning principles:

- ***Understanding*** and ***committing*** to achieving drinking-water safety are prerequisites to the implementation of any effective WSP.
- Water safety can be effectively and sustainably improved through the use of a ***preventive*** risk management approach.
- The WSP approach is meant to be ***flexible*** and ***adapted*** as needed.
- The greatest risk to drinking-water safety is contamination with ***disease-causing microorganisms***.
- Risks to the safety of drinking-water are best controlled using a ***multiple-barrier approach***.
- ***Incremental improvements*** to the water supply system can be made over time, with the aim to eventually achieve water quality targets or objectives.
- Any ***(sudden) change*** in the local environment should result in investigative action to confirm that drinking-water is safe or to provide information on how to undertake corrective actions.
- Any ***complaints*** about illness, taste, colour or smell require follow-up to ensure that the drinking-water continues to be safe.
- ***Regular review*** of the WSP (including newly identified risks) is critical to ensure that water safety planning remains up to date and effective.

Examples of small community water supplies (from left to right) in Puno, Peru; Dusheti district, Georgia; and Qaraghoch, Tajikistan. In Qaraghoch, Tajikistan, the well is opened in the morning and in the evening by a designated community member, who also distributes the water. During the winter, community members collect water from the rain and snow.

What are small community water supplies, and why are they important?

Small community water supply in Scotland. In the European Union, 1 in 10 people (40–50 million people) receive drinking-water from small or very small systems, including private wells (Hulsmann, 2005).

Small community water supplies consist of the system(s) used by the community to collect, treat, store and distribute drinking-water from source to consumer. The definition of a small community water supply can vary widely within and between countries. Some countries define small community water supplies by, for example, population size, the quantity of water provided, the number of service connections or the type of supply technology used. However, it is the operating and management challenges they face that most commonly set small community water supplies apart.

Small community water supply operators are often untrained or undertrained and sometimes unpaid. They may work only part-time and may be charged with other responsibilities within the community or privately. Many operators of small community water supplies are faced with:

- lacking access to expert assistance, because supplies are often isolated and/or remote;
- seasonal variations in water quantity and quality or occasional peak demands (e.g. during festivals or the planting season);
- receiving only limited management and technical support from water user committees or government agencies;
- having limited and inconsistent financial resources to invest in improvements and repairs.

Small community water supplies include those serving rural villages and towns, individual households and vacation homes. Water supplies serving transient populations and those in periurban areas (the communities surrounding major towns and cities) are often organized in the same way, frequently beyond the reach of municipal services. For the purposes of this manual, these can also be considered small community water supplies.

> Although the definition of a small community water supply can vary widely within and between countries, it is the operating and management challenges they face that most commonly set small community water supplies apart.

Managing small community water supplies is a concern worldwide, in both developed and less developed countries. Experience shows that small community water supplies are more at risk of breakdown and contamination, leading to outbreaks of waterborne disease and gradual decline in their functionality and service.

The greatest risks to health from these water supplies are the potential for microbial contamination and outbreaks of infectious disease, such as acute diarrhoeal illness. Every year, about 2.5 million deaths worldwide are attributed to diarrhoea alone. Approximately half who die are children under the age of 5 (WHO, 2011b).

Examples of small community water supplies (from left to right) in Manitoba, Canada; Ethiopia; and Dalvik, Iceland

What is a water safety plan?

The WSP approach emphasizes preventive risk management. It requires that risks to drinking-water safety are identified, prioritized and managed to protect drinking-water quality before problems occur. This approach draws on the methodology of sanitary inspection (see example on page 21), which offers quick results and clearly identifies action points for improvements. Water safety planning also requires regular monitoring of control measures and periodic confirmation of water quality (verification/compliance monitoring). The WSP itself documents the process and practice of providing safe water at the community level. It is vital to remember that the WSP document in itself is not the end; rather, it is a beginning. Dedicated implementation of the WSP is key. The aim of employing a WSP approach is to consistently ensure the safety and acceptability of a drinking-water supply in a practical manner.

> The WSP approach is the assessment, prioritization and continuous management of risks to water safety from catchment to consumer.

Where all risks cannot be immediately minimized because of, for example, limited resources, a WSP is implemented to make prioritized, incremental improvements over time.

Experience has shown that WSP formulation and implementation require both time and genuine commitment at all levels among key members within the community. Water safety planning should be viewed not as a one-time undertaking, but as an integral part of the ongoing, day-to-day operation, maintenance and management of the water supply, with a view to ensuring its sustainability into the future, in terms of financial support, lasting community involvement and the natural resource base.

Limitations of relying solely on drinking-water quality testing

Drinking-water suppliers usually rely on the results of water quality testing for the presence of microorganisms and other contaminants to check whether or not the water is safe to drink. Unfortunately, overreliance on such testing has several major drawbacks:

- Testing water quality is costly and cumbersome, and this is especially true for small communities.
- It is not feasible to test all water; only a fraction distributed to the community can ever be tested.
- It often takes time for water quality test results to be returned to the community or health authorities. People may fall ill before the problem has been identified.
- Water quality test results provide little information on when, why and where the contamination event occurred. Therefore, even if a water quality problem has been detected, it may not be clear what actions the community should take to correct the problem.

Testing is, and always will be, an important part of verifying drinking-water safety. However, a complementary approach is needed to better protect the consumer and lower the risk of contaminants entering drinking-water supplies in the first place.

WSP team members learning how to measure conductivity in drinking-water in Talas, Kyrgyzstan

Why should water safety plans be applied to small community water supplies?

The WSP approach is designed to help a community manage health risks that could threaten its water supply. By following the WSP approach, community members identify and prioritize health risks and, where necessary, take steps, over time, to improve the safety of the water supply using available resources. WSPs are applicable for a range of scales and levels, and in different contexts. A WSP can be developed for all existing schemes, from point sources to piped systems, as well as for new supplies. In new schemes, it should be straightforward for the supporting agency to incorporate the WSP approach into initial community mobilization and project implementation.

The development and implementation of WSPs in small community water supplies are associated with many positive impacts. Implementing a WSP will improve day-to-day risk management and operation of the water supply and will ultimately lead to consistently safer water. It provides a catalyst to develop essential skills and capacities of community members. The WSP process encourages a team-based approach, improving cooperation and engagement with stakeholders and technical experts.

Small community water suppliers may find it difficult to immediately meet community, local or national water quality targets or objectives, particularly when resources are limited. The WSP philosophy recognizes that even small, readily achievable improvements are better than none and encourages the adoption of a prioritized, "incremental improvement plan".

It is important to assess the water supply system together and collect the critical information needed to develop a WSP

Adopting an incremental improvement plan means that improvements are made over time, moving gradually towards meeting community, local or national water quality targets or objectives.

The improvement schedule laid out in a well-documented WSP should support community requests for resources to implement further water supply improvements. With a clear community WSP in hand, government and other financial supporters may be more inclined to consider supportive funding for corrective work and upgrading.

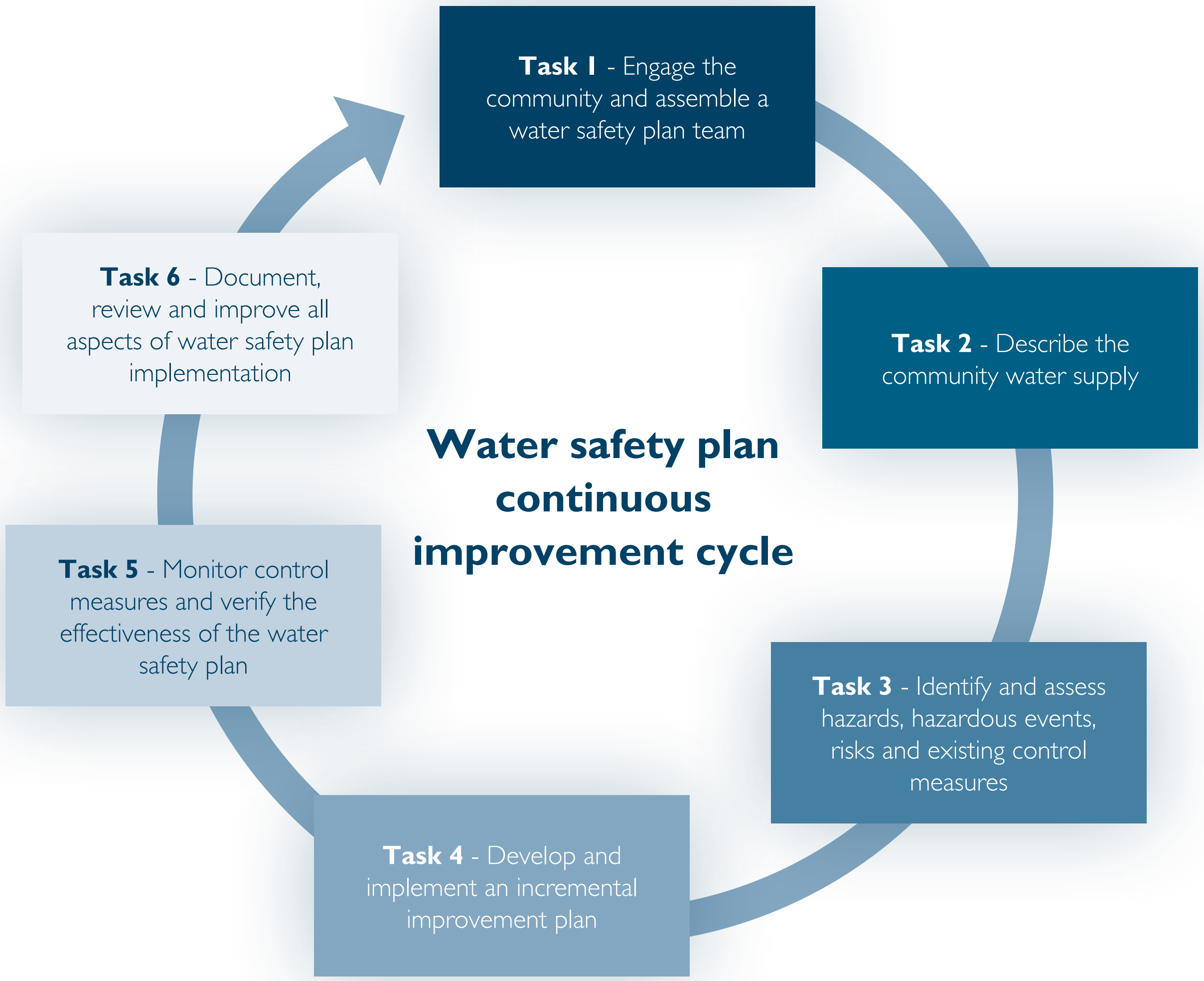
Widespread implementation of WSPs in the long term can contribute to reducing the fraction of the national disease burden attributable to poor drinking-water quality and inadequate sanitation and hygiene and likely lead to cost savings and more sustainable water management practices—critical in the face of increasing water scarcity. Additional impacts may be improved hygiene awareness together with changes in sanitary behaviour.

How can a water safety plan be developed and implemented in a small community water supply?

The process of developing a WSP for community-managed supplies can be broken down into six tasks. These tasks have been illustrated by several practical examples of what has been effective for some WSP implementers. These examples highlight that flexibility should be applied in developing and implementing WSPs to take account of local conditions and circumstances. It is up to each community to determine how best to achieve each task and establish a "living" WSP.

> The WSP approach is not a recipe that needs to be followed rigidly to achieve success.
> It is meant to be flexible and adapted to local needs.

A description of these tasks, key questions and the outcomes associated with each task is presented on the next page. While each task in developing the WSP is an integral part of the whole planning process, each task on its own helps improve the management of a small community water supply and may be undertaken or updated at any time. Each task in the WSP process is discussed in more detail in the next sections.



The six tasks to develop and implement a WSP in small community water supplies

Summary of tasks involved in developing and implementing a WSP for community-managed supplies

Task No.	Description of task	Key questions	Key outcomes
Task 1	Engage the community and assemble a WSP team	Who needs to be, should be and wants to be involved?	A community empowered through interest and ownership in the management of its water supply Support from health and water staff in the concerned administrative unit (e.g. district, block, parish) and/or from experienced NGOs Linkage to prevailing government policies, water quality standards, laws and local by-laws
Task 2	Describe the community water supply	Have we accurately captured the details of our water supply system?	Proper documentation of the community water supply (with drawings, maps, photos, water quality records and relevant management and institutional records)
Task 3	Identify and assess hazards, hazardous events, risks and existing control measures	How serious is the risk of a hazard causing harm?	Improved knowledge of hazards and hazardous events and associated risks to public health in the system Improved understanding of how the risks are currently being addressed (what control measures are in place and whether they are suitable and effective) and what risks may need further control
Task 4	Develop and implement an incremental improvement plan	How do we get to where we want to be?	Scoping of opportunities to improve drinking-water quality (by new or modified control measures) Priority actions identified to improve management and safety of the supply, including proposed timelines and needed resources Engagement of the community in implementation of the improvements
Task 5	Monitor control measures and verify the effectiveness of the WSP	Are the control measures and the plan working?	Operational monitoring and inspections demonstrating that control measures continue to work effectively Verification that the WSP is appropriate and working effectively to provide safe drinking-water
Task 6	Document, review and improve all aspects of WSP implementation	What do we need to do to ensure that our WSP works well and to improve it continuously?	Well-established management procedures for normal, incident and emergency situations shared with the WSP team and those responsible for managing the community water supply Supporting activities established to embed the WSP approach into water supply operations (e.g. training and education) Establishment of processes to review the WSP periodically, ensuring that the WSP remains up to date and effective, resulting in incremental improvements to water safety

Task 1 Engage the community and assemble a water safety plan team

Engaging the community and assembling a WSP team are an essential means to:

- identify the community's aspirations and needs in respect of their water supply, through an inclusive process that considers gender as well as elderly and vulnerable community members;
- balance water supply needs against competing community-level priorities, such as housing and education;
- tap into local knowledge and experience in the identification, assessment and management of risks;
- identify resources within the community that can be called upon when needed;
- initiate a dialogue between the community and other stakeholders (government, NGOs, water service delivery and public health agencies) on the benefits and requirements of a well-functioning water supply and the joint preparation of a WSP;
- raise awareness of the role that community members can play in protecting and improving their water supply.

A successful WSP will have involved the community throughout the entire process and, ideally, is led at the community level.

How to do it

1.1 Engage the community

For successful implementation of the WSP, it is important that the community, particularly community leaders and decision-makers, understands the benefits of the WSP approach. Buy-in from decision-makers for the WSP process is needed to obtain support for changes in the operation, maintenance and management of the community water supply and to ensure that sufficient resources are available.

The community as a whole can be engaged in a number of ways. It is generally more efficient and effective to identify suitable members of the community to represent the community's interests as part of a WSP team. Other methods of engagement include, for example, public meetings, participatory techniques (e.g. participatory rural appraisal, mapping, transect walk, pocket chart; see Glossary) and subgroup (corner) meetings by service areas or interest groups (women, the poor, farmers). A visit to a nearby community that has successfully applied a WSP is a good way to trigger interest in the approach.

> Active ownership by community members in the operation, maintenance and management of their water supplies is crucial in small communities.

Meeting with community members in Pendzhekent district, Tajikistan

Corner meeting in Tharpu, Nepal

From left to right: Chairman, accountant and plumber of the Anbukhaireni WSP scheme committee in Tanhu district, Nepal, in front of the scheme map including 600 household connections, made as part of the development of a WSP. The leadership of the chairman and the effective linkage between this community scheme and the district water office has enabled continuous improvement since completion of the scheme in 1995, with a focus on water treatment and quality in the last two years as part of the WSP. The majority of investments have been made using revenues generated by the scheme itself.

1.2 Assemble a WSP team

The WSP team will be responsible for developing, implementing and maintaining the WSP. The team is also needed to help the community to understand and accept the WSP approach. When choosing WSP team members, it is best to consult community leaders, such as elders, elected officials or other persons who know the community well. Ideally, team members will have varying backgrounds. People who have one or more of the following characteristics should be considered for team membership:

- is familiar with, and uses water from, the water supply;
- is responsible for the day-to-day operations of the water supply or has helped during construction or earlier repairs;
- has the authority to make decisions about spending money, training, recruiting staff and/or making changes to the water supply;
- has the knowledge and capacity to identify and characterize potential risks to the water supply from the catchment to the consumer;
- is responsible for or has the capacity to help manage and prevent those risks;
- is influential and interested, at both the community level and at least one administrative level up, in representing water quality concerns and investment needs at the district level or higher.

It helps to include people with knowledge of the catchment area (e.g. land owners and users) and of the history of the water supply in the community (e.g. community elders), those with the greatest interest in safe water (often women) and those who can influence how the water supply is managed (e.g. community leaders and opinion leaders). Health staff and teachers should also be considered as members or resource persons.

It is recommended that the WSP team involve local or regional government officials, particularly those with experience in drinking-water related issues, early in the WSP process. These may also include district or community health workers and environmental/agricultural extension workers. Depending on the local regulatory environment, it is wise to ensure upfront that regulatory requirements or restrictions for the water supply system are taken into account. Local officials may have access to this information.

Need for external support

Small community water supplies may require independent external support systems at national, regional and local levels, such as:

- training and education to build understanding and expertise;
- technical advice and guidance;
- financial and management support;
- monitoring of services and water quality;
- surveillance and independent oversight.

Outside experts can provide useful advice and expertise, even if they are not full-time members of the team. They can provide assistance in identifying hazards and prioritizing risks and, during subsequent implementation of the WSP, may facilitate support and assistance, either financial or in-kind. They will often be able to provide the community with additional information and training materials and link them with other experts, communities and practitioners. Examples of outside experts include NGOs, local consultancy firms and government projects with specialized units (e.g. the technical support units in the decentralized water sector in Uganda).

A WSP team leader should also be identified to oversee and drive WSP development and implementation efforts. This person should have sufficient authority in the community and good organizational and communication skills.

1.3 Document team membership

Once the WSP team is identified, participants' names and roles should be documented and shared with all team members and the community. An example of the type of information to be gathered is shown in Table 1.1.

Table 1.1. Example of information to capture about WSP team members

Name	Role in the community	Interest in the water supply	Address and contact details (phone/e-mail)
(Mr) Surya Nath Adhikhari	Chairman of the water user committee	Helped construct and maintain the system since its initiation	Kalika VDC, Ward No. 6, Sunpadali, mobile 98460 31617
(Mrs) Anjali Shrestha	Public health officer	Controlling dysentery and occasional outbreaks of typhoid	Pokhara Nagar Palikha, Ward No. 27, opposite Everest Primary School, mobile 98560 87251
(Mr) Tika Ram Prajapati	Farmer with land near the intake	Using water from the same watershed	Kalika VDC, Ward No. 9, Dhimal Chowk

Tips

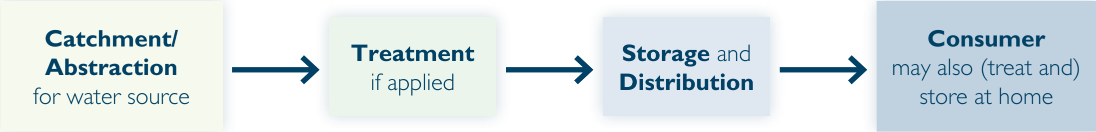
- » When the team composition is posted on the local notice board, it may be helpful to include a photograph of each person on the team. A photograph makes the notice more attractive, potentially raising interest, while also acknowledging community members for their inputs.
- » It may not be possible to bring together the entire team right at the beginning. This is normal and should not slow down the process. Part of the WSP process is to identify gaps in the community's knowledge and expertise and to work together to fill those gaps. New members can easily be added later in the process, or persons with specific expertise (e.g. a public health officer or a teacher) may need to be invited for a few sessions only.
- » The WSP team should plan to meet regularly to develop, implement and review the WSP. It is likely that more meetings will be needed during the initial stages of WSP development. As WSP implementation progresses and the team becomes more familiar with the WSP approach, fewer meetings may be required.
- » Community engagement should not be limited to the start of the process. It is beneficial to try to engage community members throughout the WSP process and mobilize them for each of the main tasks. It is important to focus particularly on women, as they are often responsible for water collection and family health, and schoolchildren, who can study aspects of the system (e.g. types of animals and crops in the catchment).
- » An annual water week (or day) festival focusing on water safety, water quality, sanitation and hygiene, organized in the community, is a good way to raise interest and may make it possible to generate the resources for improvements. For example, the WSP team could consider planning an event around already established community events or around World Water Day (22 March) and linking it with any activities being planned in the region by other stakeholders, including government and NGOs.
- » In new schemes, it should be easier to incorporate the WSP approach in the community mobilization and planning phase. In existing schemes, a fresh effort may be needed to raise interest and generate a community drive for developing and implementing a WSP.
- » Government and NGOs should be engaged from the beginning, as they may be interested in and able to provide support for developing and implementing a WSP.
- » The WSP team may wish to explore partnership arrangements for peer-to-peer support. Partnerships could be formed between two neighbouring communities to facilitate knowledge exchange for community-managed supplies that are both initiating a WSP or where a community experienced with the WSP approach would help the other community in setting up the WSP process. Partnerships could also be formed between a larger organized supply and a community-managed supply, where the larger supply would support the community-managed supply.

Outputs:

- A team of individuals representing the community's interests:
  - with knowledge of the water supply system and how to identify and prioritize potential risks to the community water supply, including health, social, environmental, development and physical planning considerations
  - with interest in promoting sustained access to safe drinking-water
  - who can help mitigate risks
- Support from relevant government units and NGOs

Task 2 Describe the community water supply

The WSP development process provides a framework to give the community a better understanding of the health concerns related to their water supply and empower it to act through ownership over its water supply. A complete map and description of the water supply system are a precious source of information that will help the WSP team and the community members identify hazards and their potential impacts on water safety.



Components of a piped water supply system

A community water supply system may be made up of a number of connected components, as illustrated for a piped scheme above. Alternatively, a community may have several point water sources (e.g. protected springs, wells, boreholes, rainwater harvesters) serving tens or hundreds of households. The WSP team should check all of these sources and include them in the community WSP.

How to do it

2.1 Draw a map

The first task of the WSP team will be to understand what is in place. An easy way to do this is to make a map/flow diagram of the water supply, including relevant elements of the catchment area and the community served. A great deal of information can be recorded and presented in a drawing. Such mapping of the community water supply from catchment to consumer is an essential part of the water supply description.

Mapping the community water points in a community in northern Nigeria

Simple maps prepared with pencil and paper may be used. Specialized equipment and/or skills to develop maps are not necessary. However, maps should be sufficiently detailed to easily identify hazards and risks to the water supply. Therefore, when a community water supply is made up of a number of connected components, it may be helpful to develop an overview map of the entire community supply as well as detailed maps/schematics of each water supply component. For example, a catchment map should include human activities and land uses (e.g. agriculture, sanitation) that may contribute to microbial and/or chemical contamination of the water source, whereas a treatment map should provide details on the treatment processes used, where particular chemicals are added, etc. Useful starting points include local road maps and information from those who assisted in the design and construction of the water supply. These individuals often have maps and technical drawings that can be copied.

2.2 Gather supporting information

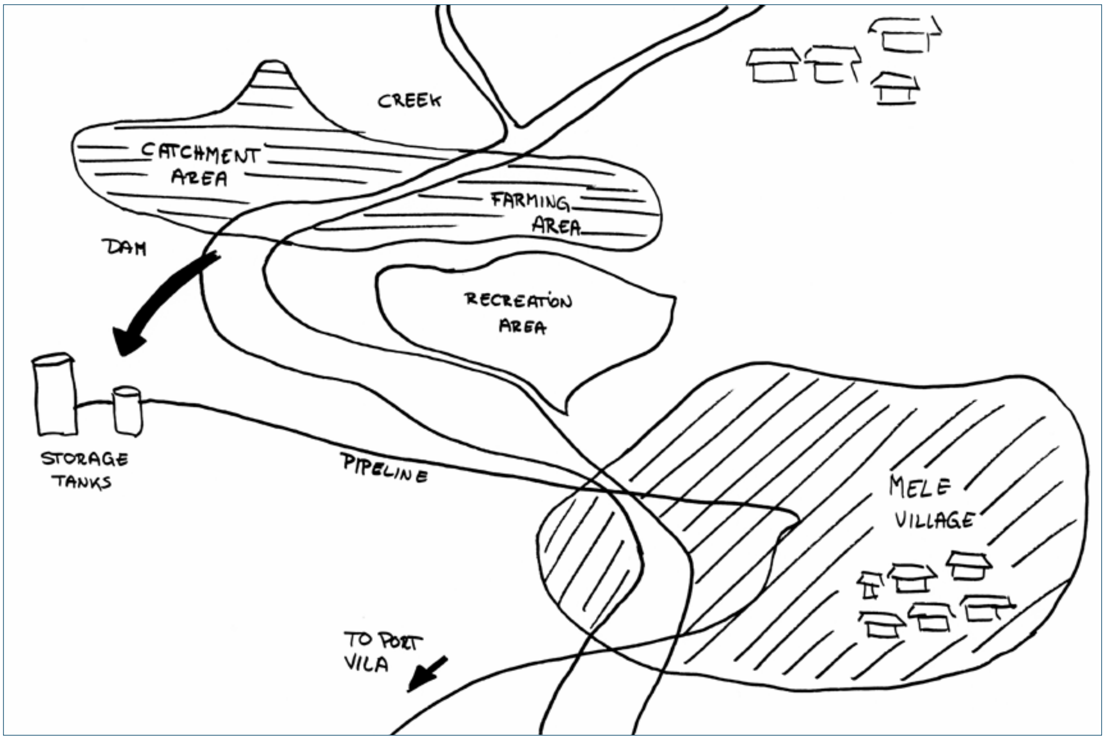
General information also needs to be gathered and recorded to describe the water supply and its management, including the various sources in use. The type of information collected should include, but is not limited to:

- relevant water quality standards;
- known or suspected changes in source water quality relating to weather or other conditions;
- details relating to the land uses in the catchment;
- details relating to the treatment, distribution and storage of the water;
- who uses the water supply and for what purpose;
- the person(s) currently responsible for operating the system and what education and training they received;
- what financial and human resources are available for managing and operating the supply;
- management procedures (e.g. operations, maintenance, inspection), if they exist;
- the legal ownership of land used and other properties in the catchment;
- details on existing sanitation facilities, including their location.

Case-study: System mapping in Guyana

Through the development of a detailed schematic for a simple treatment system involving storage and chlorination, it was revealed that chlorine was added following storage and immediately prior to distribution, allowing only a few minutes of contact time before the water reached the first customers. Drawing the detailed map led operators to investigate the chlorine addition point, which was previously unknown and not considered. Without the development of a detailed schematic, this important risk would have been missed.

Table 2.1 provides guidance on how to describe each of the major components for the example of a piped water supply. This is not an exhaustive list, nor is each point relevant for every small community water supply. The local water office will often have more extensive guidance. Similar template lists for hand pumps or protected springs may also be available from the local water office or NGOs.



Water supply system in Mele, Efate, Vanuatu

Table 2.1. Examples of factors to be considered when describing the major components of a piped water supply system

Catchment/abstraction	Treatment	Storage and distribution	User installations
Catchment: What are the characteristics of the water source(s) (e.g. quantity and quality)? Are there seasonal or weather variations? What is their impact on the quality and quantity of the water source(s)? Where are the catchment and recharge areas? What are the catchment characteristics, including details on land use (e.g. household, sanitation, industry, agriculture, wildlife)? **Abstraction (for spring boxes, wells, boreholes, streams, etc.):** Where is the abstraction point located, and how does it operate? What human activities take place near the abstraction point? What types of sanitation facilities are in the community (or is open defecation being practised)? Where are these sanitation facilities located? What is their distance from the abstraction point? What is the abstraction infrastructure made of, and how old is it? What is the capacity/flow of abstraction? Are there protection measures around the abstraction area (e.g. fencing, grating)?	What water treatment processes are in place, and how are they configured? What chemicals and materials are used for treatment? What are the availability and quality of the chemicals? How are they stored? Is the water disinfected? If so, what methods and disinfectants are used? Is there sufficient disinfectant (e.g. chlorine) contact time for proper disinfection? Is water quality monitored? How? How often? Where? Are treatment plant operators trained? Are there minimum competency standards, and do operators meet such standards?	Are the storage tanks protected (e.g. rainproof with gutters)? Are there screens on ventilation and overflows to prevent vermin and animal entry? Is there adequate protection/security on storage tanks with locked gates and hatches? Are there separate inlets and outlets at varying heights on opposite sides of tanks to promote good mixing? What construction materials are used in the infrastructure, and how old is the infrastructure? Does the distribution operate constantly or intermittently? Is there secondary disinfection, and, if so, are chlorine residuals in critical points in the system monitored and recorded? What is the average pressure in the system, and does it vary? What is the flow rate at the tank inlet and tap points in the system? Is water quality monitored? How? How often? Where?	What are the current water uses (e.g. drinking, preparation of food, personal hygiene, clothes washing, domestic livestock, vegetable farming, fish market) and future needs (quantity and quality)? What are the numbers and type of users, including commercial users (e.g. homes, hotels, guesthouses, institutions, workshops, small industry)? Are there any vulnerable groups or special needs within the population, including the infirm or sick and aged? Are there hospitals and schools? Do households treat and store water? By what means? How is water collected and transported? Are stand posts and house connections inspected, and is water quality tested? How? How often? Is water quality monitored at stand posts and at households? By whom? How often? What education/training has been given to the community about its water supply? How is wastewater handled? Is there backflow prevention? What material is used for domestic pipe work, and how old is it? Are consumers aware of regulatory requirements for drinking-water quality (e.g. drinking-water standards)?

Understanding the catchment area

A good understanding of the catchment area is an important part of the system description and facilitates hazard identification in the next task. The catchment, or drainage basin, is a discrete area of land that has a common drainage system. A catchment includes both the water bodies that convey the water and the land surface from which water drains into these bodies (Helmer & Hespanhol, 1997).

It is important to understand where the source water originates. For wells, boreholes or springs supplied by groundwater, investigation may be required. The groundwater may be of local origin, or it may have travelled underground for a considerable distance. Local knowledge can often identify where the water originated, but, if needed and resources are available, a local or regional hydrogeologist should be asked for advice. Further information can also be found in *Protecting groundwater for health* (Schmoll et al., 2006).

It is likely that the catchment area will not be fully understood in the beginning. Nevertheless, it is critical to take steps to better understand the catchment with existing resources. The system description can be updated at a later date once additional resources and skills become available.

2.3 Check the map and water supply description

It is important for the WSP team to physically check the description of the water supply system through a walk or site inspection (e.g. by following the "flow of water" through the water supply system). Taking photos and reviewing related documentation can also be useful. The water supply map and description should be updated based on this check. This activity could also be conducted as part of 2.1 (drawing a map).

2.4 Discuss and identify community water supply objectives

The following questions can help in developing holistic community water supply objectives:

- What do we want and need from our water supply?
- What are our current water supply and sanitation systems, and how are they operated?
- What problems are there with the water supply?
- Who is involved, and who should be involved, in ensuring that we have the water we need and want?
- What else, other than the water supply, is needed for a healthy and sustainable community?
- What other water supply aspects should/can be considered (e.g. other activities for which water is needed, such as fruit and vegetable gardening, growing rice seedlings for transplanting, domestic livestock)?

It is important to discuss the benefits of safe drinking-water and good hygiene with the community and the linkages among water supply, sanitation and hygiene. Hygiene education and health promotion activities, received via other community members, from public health staff, by mass media or while in school, should be reinforced. With understanding comes an appreciation of the value of hygienic behaviours on health, opening the door to sustained behaviour change.

Discussing the results of community mapping of water points in Baganbari slum, Dhaka, Bangladesh

Tips

» Often information is already available in the community. Members of the WSP team should be a useful source of information, as well as community members and outside experts.

» It is important to record the date on any drawings or documents, because situations change over time.

» During the mapping of the water supply, all sources should be visited.

» For new or upgraded supplies, system information should be documented right away before memories begin to fade.

» If the capacity exists locally and costs are affordable, arrangements should be made with the local health or water office to test water samples from the community water supplies and source waters. The community may also want to record other indicators, such as continuity of service and aesthetic qualities (e.g. colour, smell). This will contribute to establishing a baseline on water quality and quality of service, reflecting the situation at the beginning of the WSP process, against which the impact of the improvements can be measured.

» The local water or health office, or sometimes the local authority, can inform the WSP team and the community about relevant national public health regulations and laws, including the national drinking-water quality standards and associated policies and implementation strategies.

» Each community and its circumstances are unique. Each community must have the opportunity to develop its own objectives. External resource persons or local government may help with the process to ensure that the objectives meet or exceed legal requirements for the community water supply system.

Outputs:

- Maps/drawings and descriptions of the community water supply from catchment to abstraction, treatment, storage, distribution and the consumer, as applicable
- Identification of the users and uses of the water

Task 3 Identify and assess hazards, hazardous events, risks and existing control measures

The process of hazard identification involves identifying actual and potential dangers and their causes. Hazard identification should be based on community knowledge (including historical information), recurring local events (e.g. heavy runoff or floods during heavy rainfall periods or thaw), checklists included in water supply guidelines or developed by local water or public health offices, sanitary inspections and expert advice.

It is also good practice to keep track of events and risks that may arise due to changes in or around the system as a result of land use changes, construction, new industry, etc. Keeping the WSP up to date and valid is critical and will pay off in reduced risk and less damage during unexpected events.

What are the most common hazards?

When people fall ill not long after drinking the water from the water supply system, it may indicate that drinking-water has been contaminated with microbial pathogens or, much less commonly, poisoned with chemicals from industrial or agricultural accidents. Between 1991 and 2002, 207 waterborne outbreaks were reported in the United States, of which only 16% (33) were attributed to chemical rather than microbial contamination (Craun, 2006).

In addition, hazardous chemicals may occur naturally in, or contaminate, the source water through runoff or leaching. High, but not immediately toxic, levels of chemical contaminants in drinking-water can lead to chronic or long-term health issues that may show up in the population only after many years.

Aesthetic concerns, while not directly health related, can have an important impact on overall water safety in a community. For example, water that is safe but has a bad appearance, taste or odour may not be accepted by consumers and may lead them to seek out other, aesthetically acceptable, but less safe, alternatives. Conversely, water that tastes good has a positive impact on people's general feeling of well-being and potentially on the overall vitality and sustainability of the community.

How to do it

3.1 Look for signs of hazards and hazardous events

When identifying hazards and hazardous events, the WSP team should first look for signs that may signal issues caused by contaminated water supplies. Some common signs are presented in Table 3.1.

Hazard: A biological, chemical, physical or radiological agent that can cause harm to public health. *If people use empty pesticide containers to collect drinking-water, the pesticide residues that are likely to contaminate the water pose a clear health hazard.*

Hazardous event: An incident or situation that introduces or amplifies a hazard to, or fails to remove a hazard from, the water supply. *Heavy rainfall is a hazardous event that may create pathways for microbial pathogens in excreta (the hazard) to enter the source water, distribution system or storage tank.*

Risk: The likelihood of a hazard causing harm to exposed populations in a specific time frame and the magnitude and/or consequences of that harm. *The practice of open defecation creates a risk associated with microbial pathogens in human excreta, especially during rainfall, as runoff containing human excreta is likely to contaminate drinking-water sources with disease-causing organisms.*

Recent road construction exposed a section of buried mains high-density polyethylene pipeline for a water supply system in Nepal. A vehicle can damage this pipeline (hazardous event), potentially causing disruption of safe water supply to some 70 households (risk).

Table 3.1. Signs that may signal acute or chronic health-based and aesthetic issues caused by contaminated water supplies

Potential signs	Possible hazards (and other issues to consider)	Contamination source/hazardous event
Acute water-related health issues		
Diarrhoea and dysentery (including occasional outbreaks of cholera and typhoid fever) and other waterborne infections such as hepatitis are widespread within the community, particularly affecting the young, old and health compromised	Microbial pathogens	Open defecation or nearby sanitation facilities cause faecal matter to enter the source water or the system Source contamination from agriculture (use of manure) or wildlife Dirty water with suspended particles such as silt, clay or organic matter, often from flood waters or following rainstorms
Methaemoglobinaemia in bottle-fed infants	High levels of nitrates/nitrites with associated microbial contamination and diarrhoea	Sewage discharges, poorly maintained septic tanks, animal manure and runoff from agriculture
Chronic water-related health issues		
Mottling and staining of teeth in young children and teenagers, brittle bones and crippling	High fluoride levels	Naturally occurring in some groundwaters
Pigmentation changes (melanosis) and thickening of the skin (hyperkeratosis), increased rates of cancers	High arsenic levels	Naturally occurring in some groundwaters
Skin irritation (skin rash, hives, itchy eyes and throat), tingling around the mouth and fingertips, slurred speech; animals who drink the water may die	Algae and algal toxins	High nutrient levels in warm and stagnant surface water (ponds, tanks), resulting in algal blooms, which may release toxins
Aesthetic issues		
High corrosion rates of metals in contact with water	High metal concentrations; may pose health concern in some cases (e.g. lead)	Soft, acidic water (e.g. rainwater) in contact with unprotected metal pipes and fittings
Stains on fixtures or laundry, coloured water with metallic taste	High metal concentrations • copper (green/blue-coloured water or stains); may pose health concern • iron (brown/red-coloured water) • manganese (black/dark brown stains)	May result from corroding pipes in the distribution system; in tubewell supplies, it may be naturally occurring in groundwater with elevated iron and manganese levels or from "overturning" of reservoirs
Unpleasantly salty taste	High sodium chloride levels; may pose health concerns to those on sodium-restricted diets	Naturally occurring in some groundwaters, may be from seawater (coastal areas) or caused by runoff of road salt (cold climates) or evaporation residue in irrigated areas (hot climates)
Rotten egg odour and taste, corrosive black spots in pipes	High sulfide levels; usually not harmful to health, but may be associated with high organic matter content (coloured water)	Naturally occurring in some groundwaters, but could indicate industrial waste, oil, coal or stagnant water
Brown-coloured water without particles	High levels of natural organic matter; could result in high levels of disinfection by-products if water is chlorinated	Naturally occurring in some surface waters from lakes or rivers with submerged vegetation
Soap does not lather, white scale builds up on pots or kettles when water is heated	High hardness (calcium and magnesium); not harmful to health, but may make the water difficult to treat and use	Usually from limestone and chalk aquifers

3.2 Identify hazards and hazardous events

The WSP team should identify hazards and hazardous events for each stage of the drinking-water supply by asking the questions:

What can go wrong? How, when, where and why?

For each component identified in the water supply map, the WSP team should identify the relevant hazards and hazardous events. Some are obvious, and others need reflection and on-site checking. Their occurrence and control depend on many factors, including:

An unprotected public water collection point in Fayzabad district, Tajikistan

- type of source water (surface water, groundwater, rainwater);
- how the water is distributed (piped, carried, storage, materials used, distance and time);
- location (hillside, flood-prone area, near roads or developed areas);
- social situation (public or private taps, personal hygiene practices, waste and wastewater disposal, supply also used for animal watering or crop irrigation);
- energy supply and mechanicals (availability, reliability and location of fuel and electricity, maintenance and spare parts);
- hours of supply (intermittent, permanent or only dry season);
- availability of chemicals and funds for treatment and distribution.

The WSP team should consider not only the obvious hazards and hazardous events associated with the water supply, but also the potential for them to occur or be compounded through:

- lack of understanding of the water supply system and how to operate it;
- operational failures, as a result of power shutdown or disruption;
- various shortcomings associated with faulty infrastructure;
- treatment failures, including equipment breakdown or operator error;
- accidental contamination;
- natural hazardous events, including heavy rainfalls, thaw, landslides, floods or droughts;
- human-made disasters, resulting from neglect or sabotage.

The team members may identify many issues, depending on their experience and expertise. Care must be taken to reflect the real importance of the hazard in each situation. There is little value in preparing a "shopping list" when the hazard identified is not relevant to local circumstances. (Note that an evaluation of the hazard and hazardous event, in terms of how likely it is that the event will occur and its impact if it occurs, is described in 3.3.)

Some of the hazards and hazardous events that can occur, which the WSP team may want to consider, are indicated in Table 3.2. This is not an exhaustive list, nor is every point relevant for every small community water supply. The WSP team should ensure that special situations that pose a real associated risk in their community but are not listed in the table (e.g. filthy runoff from the slaughtering site at the weekly local market) are addressed. Local water or public health offices may have additionally developed locally relevant checklists.

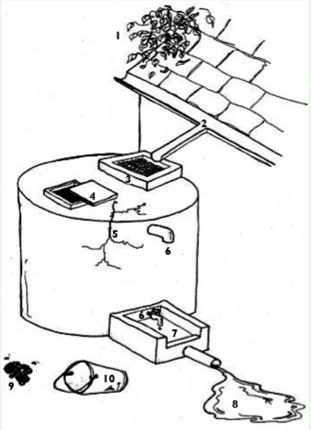
Table 3.2. Examples of hazards and hazardous events organized by different components of a drinking-water supply

Catchment/abstraction	Treatment	Storage and distribution	User installations
Acute health risk due to disease-causing microorganisms in drinking-water			
Rainstorm events and heavy rainfall causing high pollution load (due to runoff) Septic tanks in catchment and raw sewage causing faecal matter to enter water source Swimming, boating, fishing or other human activities possibly introducing faecal material Wastewater or urban stormwater discharge/local flooding Intensive animal farming around shallow groundwater wells Cracked spring box, well or borehole infrastructures, allowing ingress of faecally contaminated runoff or leachate Direct access of animals to abstraction infrastructures Latrines nearby water abstraction, introducing contamination	Microbial pathogen loading exceeds treatment removal capacity (e.g. chlorine concentration and contact time insufficient) Failure of disinfection system Short-circuiting within tanks, (e.g. some water to be treated passes too quickly through the treatment tank as a result of flaws in tank design, such as to the inlet/outlet)	Access to service reservoir by humans or animals, including insects and birds (e.g. lack of screen at air vents) Ingress of contaminated runoff through service reservoir inspection covers Inflow of contaminated roof drainage to service reservoir Poor cleaning of pipes and tanks Contamination of collected water because of the use of containers or jerry cans without a screw cap and poor hygienic practices associated with containers Pipe breakage due to old pipes or road crossing Contamination from broken sewerage pipes Low pressure or intermittent operation causing influx of contaminants Insufficient residual chlorine	Contamination of domestic water because of poor hygienic practices associated with storage containers (e.g. storage in wide-mouthed, uncovered containers or hand dipping of cups) Rainwater system without functioning first-flush discharge device or filter No place to hang the bucket to keep it clean when using an open well Cross-connections with non-drinking-water systems in the home Insufficient residual chlorine
Acute health risk due to short-term exposure to hazardous chemicals in drinking-water			
Excessive or inappropriate use or inappropriate disposal of pesticides, insecticides, herbicides, etc. in agriculture Wastewater discharges containing high concentrations of industrial chemicals (e.g. cyanide spilt to sewer) Chemical spills or industrial accidents Algal blooms in reservoir (toxins)	Overdosing and contamination with chemicals (e.g. fluoride, alum) No treatment for specific chemicals or toxins, or exceeding the treatment limit	Cross-connections from chemical storage	Backflow from a household or institution (hospital, workshop, garage or small factory including chemical storage)
Chronic health risk due to medium- or long-term exposure to hazardous chemicals in drinking-water			
Naturally occurring fluoride or arsenic in groundwater Pesticide and fertilizer use (e.g. in plantations, agriculture and horticulture) Leaching from waste upstream of community water sources (e.g. solid wastes, mining wastes, contaminated landfills) Frequent urban stormwater discharge (runoff of high concentrations of heavy metals and hydrocarbons) Leakage/waste of hydrocarbons and other chemicals from commercial sites or fuel stations Improper disposal of chlorinated solvents used for degreasing, resulting in high concentrations in groundwater	Overdosing and contamination with chemicals (e.g. fluoride, chlorate from poorly stored hypochlorite)	Corrosion of materials used (copper, lead)	Corrosion of materials used in domestic plumbing (copper, lead) Continued use of a domestic filter, when the filter medium is exhausted (arsenic, fluoride) Cross-connections with non-drinking-water systems in the home
Aesthetic issues			
Soil erosion and runoff (high turbidity) Stratification, overturning of reservoirs (high iron, manganese levels) Heavy rainfall or thaw (high turbidity, colour) Excessive use of tubewell during drought (high turbidity)	Treatment malfunctions (e.g. high chlorine, alum levels) (taste, odour, colour, high turbidity)	Material corrosion (high iron levels) Stagnant water in pipes or tanks due to poor design and operation (e.g. dead ends, low points) (taste, odour, colour) Increase or reversal of flow, causing scouring, stirring or sloughing of accumulated sediments and biofilms (high turbidity) Poor cleaning of pipes and tanks (taste, odour, high turbidity)	Material corrosion on internal galvanized pipe work (high iron levels) Stagnant water in internal system

Importance of sanitary inspections

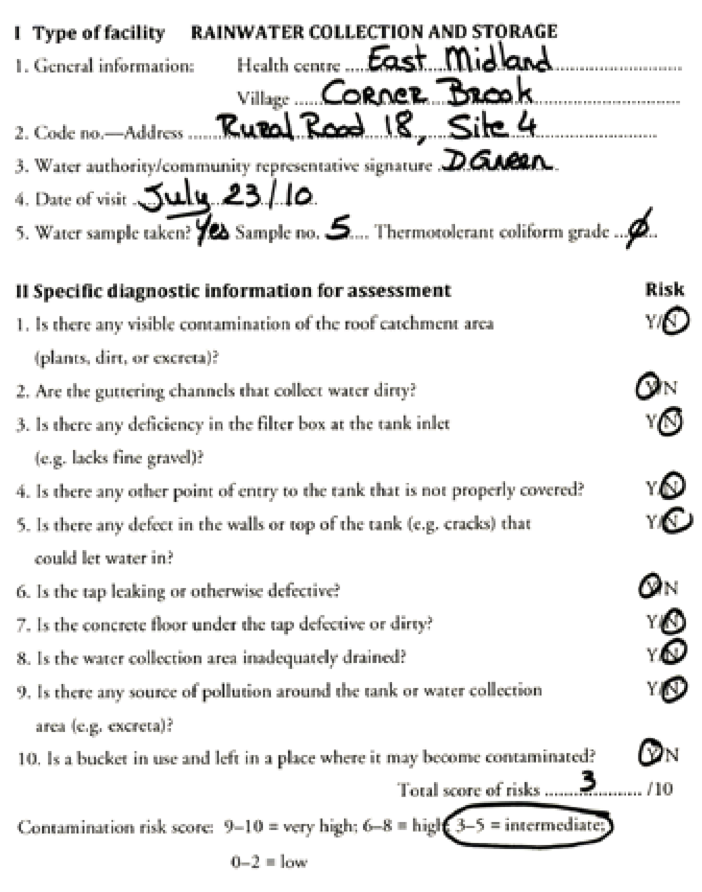
Sanitary inspection is a powerful on-site fact-finding activity that can strongly support WSP implementation. It can be particularly useful in systematically identifying potential hazards and hazardous events, thus informing the risk assessment process. Sanitary inspection specifically:

- assists in identifying potential contamination sources that would be missed by water quality analysis alone;
- supports adequate interpretation of water quality laboratory results;
- provides information about known, immediate and ongoing contamination;
- provides a longer-term perspective on causes of contamination;
- enhances knowledge of the water supply system;
- evaluates the effectiveness of operation and maintenance procedures.



Sanitary inspection typically makes use of standardized "sanitary inspection forms" containing a systematic checklist of a limited number of specific questions (often not more than 10 or 12 per form), which can be answered by the assessor using a mixture of visual observation and interviews on-site. The sanitary inspection form shown to the right demonstrates this approach for a rainwater tank supply, where each question answered with "yes" represents a risk. An important feature, and benefit, of this approach is that it both gives a score related to risk and makes it apparent what improvements could be made to reduce that score, and hence reduce the risk.

Sanitary inspection tools are available for a variety of situations and water supplies. Examples of sanitary inspection forms are included in Annex 2 of the WHO *Guidelines for drinking-water quality*, Volume 3, *Surveillance and control of community supplies* (WHO, 1997), available at http://www.who.int/water_sanitation_health/dwq/2edvol3h.pdf. Sanitary inspection forms should be designed to match local circumstances. National or regional agencies may have developed or be promoting a specific tool for use; the WSP team should consult with district or national officials to find out what already exists (e.g. localized inspection forms in national or local languages).



I Type of facility **RAINWATER COLLECTION AND STORAGE**

1. General information: Health centre East Midland
Village Corner Brook
2. Code no.—Address Rural Road 18, Site 4
3. Water authority/community representative signature D Green
4. Date of visit July 23/10
5. Water sample taken? Yes Sample no. 5 Thermotolerant coliform grade 0

II Specific diagnostic information for assessment **Risk**

1. Is there any visible contamination of the roof catchment area (plants, dirt, or excreta)? Y/[✓ N]
2. Are the guttering channels that collect water dirty? [✓ Y]/N
3. Is there any deficiency in the filter box at the tank inlet (e.g. lacks fine gravel)? Y/[✓ N]
4. Is there any other point of entry to the tank that is not properly covered? Y/[✓ N]
5. Is there any defect in the walls or top of the tank (e.g. cracks) that could let water in? Y/[✓ N]
6. Is the tap leaking or otherwise defective? [✓ Y]/N
7. Is the concrete floor under the tap defective or dirty? Y/[✓ N]
8. Is the water collection area inadequately drained? Y/[✓ N]
9. Is there any source of pollution around the tank or water collection area (e.g. excreta)? Y/[✓ N]
10. Is a bucket in use and left in a place where it may become contaminated? [✓ Y]/N

Total score of risks 3 /10

Contamination risk score: 9–10 = very high; 6–8 = high; [✓ 3–5 = intermediate;] 0–2 = low

Example of a sanitary inspection form and risk score for rainwater collection and storage

Case-study: Sunpadali, Nepal

When the WSP was started in Sunpadali, Nepal, in 2008, questions were raised regarding the quality of the source water when interventions did not seem to reduce occasional typhoid fever outbreaks in the community. The source water area seemed pristine, but, unknown to the Sunpadali water user committee, some 10 poor landless families had settled on level land about 100 metres in elevation above the intake. It turned out that these households were practising open defecation. The Sunpadali water user committee and the local government (which allowed these people to settle there) therefore helped the new settlers to construct latrines, and consultation and regular sanitary inspection of the source water area and the newly settled area have since prevented further microbial contamination (H. Heijnen, personal communication, 2010).

Look at the picture and reflect on the hazards/hazardous events. Some problems can be easily corrected, but this needs leadership and community commitment. See the next page for answers.

In the Northern Karamoja region in Uganda, this hand pump enclosure is opened in the morning and in the afternoon by an elder (left) who also supervises the collection of the water. Water is scarce here, and people suffer from many diseases, including skin and eye problems. The water point area is fenced with prickly bushes, so animals cannot get inside, but instead have to drink water from the trough at the end of the drain leading out of the enclosure.

Figure on previous page: What hazards/hazardous events can be identified, and what other issues should be considered?

1. Several of the containers being used to collect the water have large openings, making the vessels vulnerable to contamination after collection. Consumer education should focus on hygienic water storage and handling practices.
2. The borehole provides limited water supply (see the line of containers), and long waiting may encourage people to visit less safe water sources near their homestead during rainy periods. Consumer education should therefore also focus on effective water use (for drinking, cooking and personal hygiene) during scarce water periods.
3. The ground is not sloping away from the borehole, allowing water to cause puddles at the wellhead and making the water supply vulnerable to surface contamination.
4. Although the drain is not visible in the picture, it should be checked daily to see whether or not it has been cleaned to ensure that the water flows out of the enclosure properly and into the animal watering trough.
5. Although the watering trough is not visible in the picture, it should be at least 30 metres away from the borehole to reduce the risk of groundwater contamination from animal droppings at the water point.
6. Are the surroundings of the enclosure kept free from open defecation?

3.3 Assess risk associated with hazards and hazardous events

The WSP team can undertake risk assessments in a number of ways. Approaches vary in accuracy, complexity and effort. For WSP team members, this exercise is often a gradual learning curve of growing understanding and appreciation of the risks. Generally, it is better for the team to start with less complicated risk assessments and progress to more precise approaches as more information, skills and resources become available. This section covers two approaches that could be considered: descriptive risk assessment and risk ranking.

If possible, the WSP team should have an engineer, a scientist, a public health inspector or a similar expert from an NGO help with the hazard identification and risk assessment. They may not be needed for the whole process, but as they have broader experience, they may come up with issues that the team missed.

Descriptive risk assessment

The simplest risk assessment method is descriptive risk assessment. In this approach, the hazards and hazardous events are prioritized based on the team's judgement. For each hazard and hazardous event, the WSP team should consider the significance of each risk (see Table 3.3), reflecting on and recording how likely it is that the event will occur in the community and how serious it might be, along with a consideration of the effectiveness of any existing control measures that are in place to mitigate those risks. The WSP team should discuss and compare each listing until it agrees on which issues are of greater or lesser importance. The team should then write down the issues in order of importance and double-check the entire list to make sure that it makes sense. At the end of this process, the team has a list of issues to be addressed, with those of greatest concern at the top. Revisiting the initial listing made in this risk assessment may be helpful, as team members may have learned more about their "real life" risks in the process and may wish to adjust some of their assessments.

Undertaking a risk assessment is often a matter of knowing the system, combined with common sense. For example, broken platforms or allowing laundry to be done on the well apron can increase the potential for contamination of the well water with soap or faecal matter. In small community water supply schemes, many improvements can be made by consumers clearing and cleaning the sources and water points on a regular basis. It is a worthwhile effort that can be done with little money.

Table 3.3. Example definitions of descriptors for use in descriptive risk assessment

Descriptor	Meaning	Notes
Significant	Clearly a priority	Actions need to be taken to minimize the risk. Possible options (short-, medium- and long-term options) should be documented (as part of the improvement plan developed in the next task) and implemented based on community priorities and available resources.
Medium	Medium priority	Currently no impact on drinking-water safety, but requires attention in operation and/or possible improvements in the medium and long term to continue minimizing risks.
Insignificant	Clearly not a priority	Actions may be taken but not a priority, or no action is needed at this time. The risk should be revisited in the future as part of the WSP review process.
Uncertain	Clarification required	Further data collection or studies are required to better understand the significance of the risk. Some actions can be taken in the meantime as deemed necessary to reduce risk based on existing information, community priorities and available resources.

When the WSP team has insufficient information or knowledge available and thus is uncertain in assessing whether or not a risk is significant, risks should be clearly flagged for further investigation. Further study may need to be conducted, or views from experts may need to be sought. It is not uncommon that further information needs to be gathered for the risk assessment.

Risk ranking

The second risk assessment approach is a more formal, two-step process. This method can be applied if the community has some higher-level support (e.g. water quality unit of the district water agency or a public health inspector) or additional resources in the community. Whereas the previous method focuses primarily on listing and ranking the hazardous events, in this method, the WSP team tries to assess the likelihood of the hazardous event actually occurring and the consequence or severity of the impact of the event to the community. As a first step, the WSP team should draw up definitions for the likelihood (e.g. what is meant by unlikely, possible and likely) and consequence (e.g. what is meant by minor impact, moderate impact and major impact) categories (see Table 3.4). This should be conducted to facilitate consistency in assessments for all parts of the water supply system and over time. When the WSP team is conducting the risk assessment, it is important that its members consider the effectiveness of any existing control measures (see 3.4 for further details) that are in place, in order to help the community prioritize what actions should be taken to improve water quality in the next task.

The WSP team should then compare the listings for all hazardous events and their relative likelihood and consequences to make sure that they have been categorized appropriately. Each event is then mapped in a matrix (see Table 3.5) to get a risk ranking. To support the risk ranking, the WSP team should define what is meant by significant (e.g. high and medium) risks so that these can easily be distinguished from less significant risks (see Table 3.6). The figure on page 26 illustrates how to prioritize actions using the risk ranking approach.

Table 3.4. Example likelihood and severity definitions for the risk ranking approach

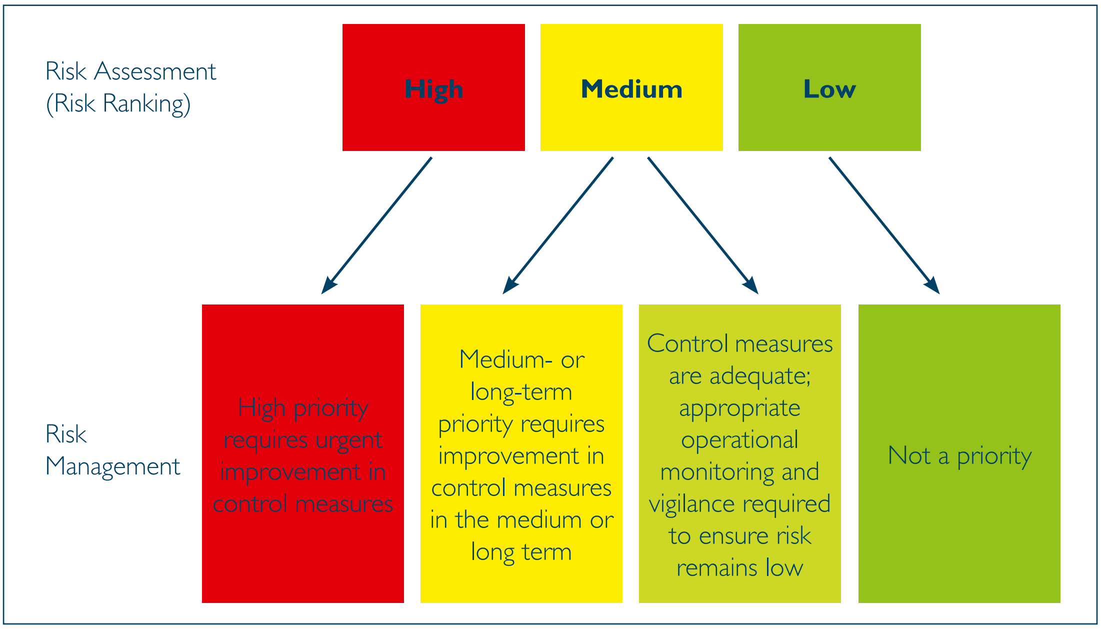
Descriptor	**Description**
Likelihood	
Likely	Will probably occur in most circumstances; has been observed regularly (e.g. daily to weekly).
Possible	Might occur at some time; has been observed occasionally (e.g. monthly to quarterly or seasonally).
Unlikely	Could occur at some time but has not been observed; may occur only in exceptional circumstances.
Severity/consequence	
Major impact	Major water quality impact; illness in community associated with the water supply; large number of complaints; significant level of customer concern; significant breach of regulatory requirement.
Moderate impact	Minor water quality impact (e.g. not health related, aesthetic impact) for a large percentage of customers; clear rise in complaints; community annoyance; minor breach of regulatory requirement.
No/minor impact	Minor or negligible water quality impact (e.g. not health related, aesthetic impact) for a small percentage of customers; some manageable disruptions to operation; rise in complaints not significant.

Table 3.5. Example risk matrix for the risk ranking approach

		Severity/consequences		
		No/minor impact	*Moderate impact*	*Major impact*
Likelihood	*Likely*	Medium	High	High
	Possible	Low	Medium	High
	Unlikely	Low	Low	Medium

Table 3.6. Example risk ranking definitions to prioritize actions

Risk ranking	**Meaning**	**Description**
High	Clearly a priority: requires urgent attention	Actions need to be taken to minimize the risk. Possible options should be documented (as part of the improvement plan developed in the next task) and implemented based on community priorities and available resources.
Medium	Medium- or long-term priority: requires attention	Actions may need to be taken to minimize the risk. Possible options should be documented (as part of the improvement plan developed in the next task) and implemented based on community priorities and available resources. **Or** where the likelihood of a hazard occurring is low because effective control measures are in place but the consequences are major (e.g. microbial risks), special attention should be given to maintaining the control measures and their appropriate operational monitoring to ensure that the likelihood remains low.
Low	Clearly not a priority	Actions may need to be taken but not a priority, or no action is needed at this time. The risk should be revisited in the future as part of the WSP review process. **Or** control measures are effective, and attention should be given to ensure that the risk remains low.



Example diagram on how to prioritize actions using the risk ranking approach

The shallow well is quite close to the toilet, raising the risk of contamination. It is better to site the well at least 30 metres away from the latrine.

Runoff of pesticide, fertilizer or manure may be a risk in many rural areas. If runoff of these contaminants could affect the water supply, zoning should be applied, stopping their use in the designated zone.

3.4 Identify and assess existing control measures

The WSP needs to identify any existing control measures or barriers that are already in place and that address potential hazards and hazardous events. Control measures can be technical (e.g. disinfection), infrastructural (e.g. fencing), behavioural (e.g. pesticide use) or related to planning (e.g. land use). It is very important to assess whether these existing barriers are effective at eliminating or reducing the identified risks; it should not be taken for granted that they are working properly. If control measures are ineffective or are not currently in place for an identified significant risk, this should be noted and suggestions for improvement listed. See Task 4 for additional information on control measures.

Unprotected well in Scotland that has since been improved!

Protected well in the Federal State of Schleswig-Holstein in Germany

Control measures (also referred to as barriers or mitigation measures): Activities and processes that can be used to prevent, eliminate or significantly reduce the occurrence of a water safety hazard.

At the end of this process, the WSP team will have a list of hazards and corresponding hazardous events to be addressed and a ranking of their priority. An example of how this list could be compiled using the risk ranking approach is shown in Table 3.7.

Table 3.7. Example of risk assessment and prioritization using the risk ranking approach

Drinking-water system component	Possible hazard	Hazardous event	Control measures	Likelihood	Consequence	Risk ranking	Priority for action
Catchment/ abstraction	Microbial pathogens	Cattle and sheep can access the well and the immediate area around it, which could result in animal faecal matter entering the water supply.	Unprotected well: no control measures in place (e.g. no fence, no wellhead protection works).	**Likely** *Justification:* Access of cattle and sheep frequently observed by community members; animal faeces are visible and can easily be washed into well after heavy rainfall.	**Major** *Justification:* Cattle and sheep faeces may contain a variety of pathogens, which may cause illness in the community.	**High**	**High priority** *Justification:* Hazardous event is likely to occur and has major consequences, and no control measures are in place. Short- and long-term measures are required.
Treatment	Microbial pathogens	Gravity-fed water supply continues to flow through the treatment works during power failures, but will not be disinfected.	Failsafe device fitted to the inlet of the treatment plant, which diverts the water if there is a power failure.	**Unlikely** *Justification:* Device confirmed to be effective during power failure, tested quarterly to ensure effectiveness.	**Major** *Justification:* Untreated source water is known to contain a variety of pathogens that may cause illness in the community.	**Medium**	**Attention required; low risk with appropriate operational monitoring** *Justification:* Exposure to microbial pathogens from the water supply is a major concern. Therefore, special attention should be given to maintaining the control measure with appropriate operational monitoring to ensure that the likelihood remains low.
Treatment	Chlorine overdose	Chlorine dosing can result in chlorine overdose if control is lost at the treatment plant.	Chlorine dosing is flow-paced to ensure consistent dosing; online chlorine analysers.	**Unlikely** *Justification:* Disinfection unit and online analyser confirmed to be effective.	**Moderate** *Justification:* Chlorine overdose can cause taste and odour problems.	**Low**	**No further action is needed; low risk with appropriate operational monitoring** *Justification:* Hazardous event is unlikely to occur and has moderate consequences, and existing control measures are adequate.
Storage and distribution	Microbial pathogens	Access to water storage tank could result in bird or other animal waste entering treated water.	Cover on water storage tank and vermin screening over vent piping, although cover has gaps.	**Likely** *Justification:* Birds and other small animals have been previously found in the storage tank; animal faeces are visible around the storage tank cover.	**Major** *Justification:* Bird and other animal faeces may contain a variety of pathogens that may cause illness in the community.	**High**	**High priority** *Justification:* Hazardous event is likely to occur and has major consequences, and existing control measure (cover) is inadequate.
Storage and distribution	Microbial pathogens/ chemicals	Low-pressure conditions (e.g. during mains breaks) can result in backflow from customer systems into the network.	Backflow prevention devices are installed at all service connections.	**Unlikely** *Justification:* Backflow prevention devices have been confirmed to be effective.	**Major** *Justification:* Backflow from customer systems into the network can introduce a variety of pathogens, resulting in widespread distribution of contaminated water to the community, which may cause illness.	**Medium**	**Attention required; low risk with appropriate operational monitoring** *Justification:* Exposure to microbial pathogens from the water supply is a major concern. Therefore, special attention should be given to maintaining the control measure with appropriate operational monitoring to ensure that the likelihood remains low.
User installations	Microbial pathogens	Contamination of treated water in household storage containers as a result of poor hygiene (e.g. hand dipping of cups).	None currently in place.	**Possible** *Justification:* Meetings held with consumers indicate that household storage is practised by some (not the majority of) consumers periodically.	**Moderate** *Justification:* Consequence is for a small percentage of consumers, but could be health related.	**Medium**	**Medium- or long-term priority** *Justification:* Hazardous event may occur and has moderate consequences, and no control measures are in place.

Tips

- » The WSP team should consider engaging other stakeholders when undertaking the hazard identification and risk assessment. Community members may reveal information about activities that can contribute potential hazards to the water supply. Outside experts, including from regional or national governments and NGOs, may need to be consulted to confirm or verify the identification of hazards and hazardous events and to ensure that the risks are assessed and prioritized in a systematic and meaningful way.
- » Identification of hazards and hazardous events should always include site visits. For example, visual inspections of wells and hand pumps and elements of treatment may reveal hazards that would not have been identified through a desk study alone. While on site visits, team members can combine system descriptions and hazard identification.
- » Additional guidance can be found in the following documents:
  - *Water safety plan manual: step-by-step risk management for drinking-water suppliers* (Bartram et al., 2009): http://www.who.int/water_sanitation_health/publication_9789241562638/en/
  - *Guidelines for drinking-water quality,* Volume 3, *Surveillance and control of community supplies* (WHO, 1997): http://www.who.int/water_sanitation_health/dwq/gdwq2v1/en/index2.html

Outputs:

- ● Description of what could go wrong and where in terms of hazards and hazardous events
- ● Description of existing control measures and their effectiveness to reduce, eliminate or prevent hazards
- ● Assessment of risks expressed in a manner that is easy to understand, interpret and rank
- ● Identification of areas for potential action based on the assessment of the hazards, hazardous events, risks and existing control measures

Task 4 Develop and implement an incremental improvement plan

In general, control measures should be designed to address the significant risks identified in the previous task. The team should review its available resources and the community's needs against the information from the risk assessment (Task 3) to identify which water safety improvements should be implemented with priority and which can be deferred for the medium or long term. When considering work to reduce or eliminate a risk, positive spin-offs, such as the opportunity to make the service more reliable or extending the service area, should be looked at. Comparing costs against *all* the benefits may generate more interest in supporting the planned work. The incremental improvement plan will be a powerful tool to ensure that limited funds, from both within and outside the community, will be used most effectively.

How to do it

4.1 Review options to control identified risks

In developing and implementing an incremental improvement plan, the WSP team must first review the significant risks determined to require additional control and, for each of these risks, list possible measures that could be put in place to address it.

The aim of control measures includes, but is not limited to:

- eliminating or reducing contaminants in the source water, thus preventing them from entering the water supply;
- removing particles and chemicals from the water or killing or inactivating pathogens (i.e. using control measures through treatment, if necessary);
- preventing contamination during drinking-water storage, distribution and handling.

When thinking about control measures, the multiple-barrier approach, which consists of an integrated system of activities and processes that collectively ensure drinking-water safety, should be considered. The advantage of this approach is that if a control measure fails, it may be compensated by effective operation of the remaining control measures, thus minimizing the likelihood of hazards passing through the entire community water supply system. Through the multiple-barrier approach, many (often small) improvements can combine to make a large difference to the quality of drinking-water.

Risks to the safety of drinking-water are best controlled using a multiple-barrier approach.

Table 4.1 provides examples of control measures that can be implemented within different parts of a water supply system. Note that not all types of control measures may be applicable in all settings.

Example of catchment control

The town of Mpigi in Uganda relies on surface water as its drinking-water source. It has a full treatment system. The water operator became aware that individuals from the town were washing their motorcycles in the water source, close to the intake point.

The water operator, in cooperation with local officials, developed a plan to address the situation. They posted signs at the water source prohibiting this behaviour.

The water operator worked with local officials to inform town members of the risks to the quality of the drinking-water associated with this practice. Random spot checks during peak "washing" times were conducted to prevent this behaviour and further educate individuals.

Washing vehicles in Kireka, Uganda. Washing vehicles in streams will affect consumers downstream.

Table 4.1. Example control measures organized by different components of a drinking-water supply

Catchment/abstraction	Treatment	Storage and distribution	User installations
Establish drinking-water protection zones with land use restrictions (e.g. no or limited activities such as agriculture, horticulture, wildlife, swimming, boating, industrial discharge). Reduce use of herbicides, fertilizers and chemicals within catchments, and only use those that are approved. Train farmers on appropriate use of herbicides, fertilizers and chemicals in agriculture and horticulture. Establish natural "buffer strips" around reservoirs, rivers and streams to minimize erosion and runoff contamination. Prevent roaming of domestic animals near the source water (e.g. fence). Switch to alternative water source(s) when something goes wrong (e.g. occurrence of algal bloom in reservoir) or when a natural contaminant (e.g. fluoride) is difficult to remove). For spring catchments: Construct a safe collection chamber and a proper overflow with elbow or tee. For surface water abstraction: Install and maintain screens and sediment traps. For all abstraction points (e.g. spring boxes, wells, boreholes, streams): Prohibit latrines and fix leaky septic tanks in the vicinity of the abstraction area. Regular cleaning, inspection and maintenance. For wells/boreholes: Slope the ground away from wellheads to prevent contamination by runoff. For rainwater catchment: Design with proper filter, first-flush mechanism and mosquito-safe tank. In designed operational areas, consider fire breaks, designated roads and tracks (to abstraction areas), adequate drainage and waste facilities, containment and bounded areas (e.g. for chemical storage). Arrange for legal right to source use and abstraction. Enforce local by-laws on hygiene, sanitation and public health.	Remove microbial contamination through reliable treatment (e.g. filtration and disinfection), with adequate capacity. Apply proven and reliable treatment to bring chemical hazards of direct health concern (e.g. arsenic, fluoride) and those with an impact on taste, odour and appearance of drinking-water (e.g. iron, manganese, turbidity and alkalinity) within acceptable limits. Note: if available, chemical removal processes should be certified for use by a relevant national authority. Even then, fine-tuning of treatment for chemical removal may require expert advice to ensure proper performance. Maximize removal of organic material prior to chlorine addition to limit disinfection by-product formation. Consider prohibiting treatment chemicals that result in taste and odour problems (but only if such actions do not compromise the microbial safety of the water supply). Ensure purity of chemicals added to water, including checking expiry dates. Ensure proper storage and availability of chemicals (i.e. stocks do not run out). Chlorinate to ensure residual chlorine in the distribution network, including in the service reservoir. Backwash filters at regular intervals to avoid excessive pressure and particle breakthrough. Prevent recycling of filter or backwash water. Install duty and standby dosing pumps to prevent treatment disruption during equipment failure. Shut off treatment plant and switch to alternative water source or treatment when something goes wrong. Backup power supplies to maintain essential treatment functions during power outages. Perform regular cleaning, inspection and maintenance of treatment installations and infrastructures. Ensure that treatment plant operators are trained and meet established minimum competency standards.	Prevent human and vermin contact with water, particularly at service reservoirs and tanks, through, for example, good roofing of water storage, adequate security (e.g. fences, locks on gates and hatches), insect-proof screens on vents and overflow pipes. Ensure that inlet and outlet pipes are at varying heights on opposite ends of service reservoir, and ensure good mixing. Regular cleaning, inspection and maintenance of storage tanks. Flush washouts in tanks and pipelines regularly. Use only materials and pipes approved for contact with drinking-water. Check and replace unsuitable materials (e.g. lead-jointed or lead service pipes, bitumen-lined mains). Aggressive water (low pH) may force use of other construction materials and plumbing. Maintain disinfectant residual throughout distribution system. Maintain constant positive pressure in the distribution system to minimize opportunities for contaminant ingress. Repair leaks to minimize opportunities for contaminant ingress. Prevent backflow into the system. Minimize dead ends in water pipes. Enforce plumbing codes, standards and licensing.	Remove illegal connections. Prevent cross-connections and backflow into the system. Institutional and home installations are carried out by recognized or certified plumbers. Educate consumers about proper hygiene and safe water storage practices (see figure on page 35 for a description of good practice). Inform consumers on point-of-use treatment options where applicable (e.g. boiling, filtration, chlorination). Distribute educational materials about safe rainwater collection practices (e.g. first-flush systems, tank cleaning).

4.2 Select control measures, and develop an incremental improvement plan to implement them

Based on the control measures identified in 4.1, an improvement plan should be developed. It is not always feasible for a small community to address every possible significant risk and put in place all possible control measures that have been identified at once. Limiting factors will include desirable time frames and available resources. Therefore, control measures to be implemented in the short, medium and long term should be identified. In developing this incremental improvement plan, the WSP team should consider:

- the level of risk associated with each hazard and hazardous event;
- control measures to address the risk (i.e. what and how);
- the person(s) responsible for carrying out the control measure (i.e. who);
- timelines for the control measure (i.e. when);
- financial resources needed (i.e. cost);
- training requirements for operating the control measure.

Some improvements or control measures will be ready for immediate implementation at little or no cost. Others will need to be addressed over time and may require a substantial budget and additional external resources. It is better not to try to do everything at once, but to use the WSP approach to make a plan with feasible and realistic time frames (e.g. for three to five years), prioritizing improvements.

The WSP team should estimate the costs and labour time associated with each improvement to provide information for decision-making. Economies that may be achieved from combining certain improvements should also be estimated.

Available resources will need to be balanced against the risk assigned to the hazard and hazardous event. The incremental improvement plan needs to be realistic and appropriate to the community's limited resources. There are often a number of ways to deal with multiple risks. The WSP team will need to consider the various benefits and costs of all the options, as well as intermediate or temporary solutions until resources become available for the preferred permanent solution.

Communities will need to decide how they will raise the funds needed for the implementation of the improvements. The incremental improvement plan will be an excellent prospectus to attract government and other interested local or external supporters to come forward and assist.

In some countries, funds can be raised as part of the regular district budgeting process. Often some matching funds from the community need to be arranged. These can be raised through water rates, loans/bonds or financial support from NGOs or wealthy community members. Although cash contributions are important, the voluntary contributions in time, services (e.g. providing hot tea and snacks to all who come to clean up the reservoir area or for the weekly pipeline checkup team) and kind should not be discounted. Community action for maintenance of the water supply also offers great opportunities for communication and information sharing and facilitates ownership of the WSP by the community.

An incremental approach allows for improvements to be made over time to achieve water quality targets or objectives. The improvement plan should be documented and shared with all those responsible for the improvement measures. A sample completed form is shown in Table 4.2.

Table 4.2. Example of an improvement plan

Hazardous events	Plan		Do		
	What	How	Who	When	Cost
Cattle and sheep can access the well and the immediate area around it, which could result in animal faecal matter entering the water supply	Exclude cattle and sheep from the abstraction area	Repair fencing around the catchment area	Mr W to arrange with local council work team	Repairs to be carried out February 2013	$175 in materials
Access to water storage tank could result in bird/animal waste entering treated water	Eliminate potential for contamination at water storage tanks	Repair leaking covers, implement an annual inspection programme (to include all system tanks) and develop a suitable sanitary inspection form	Mrs X to develop sanitary inspection form and to carry out inspections; Mr Y to make repairs	Repairs to be carried out March 2013; begin developing sanitary inspection forms by March 2013, complete by August 2013; first annual inspection in January 2014	$50 in materials
Contamination of treated water in household storage containers due to poor hygiene (e.g. hand dipping of cups)	Control potential for contamination at the household level	Develop and implement a consumer education programme (to include pamphlet distribution and information sessions at primary and secondary schools)	Mrs Z to develop and distribute pamphlets; Mr Y to present at schools	Begin developing pamphlets August 2013, complete by December 2013 Pamphlet distribution and school presentations to begin in January 2014	$30 in materials

Note that it is essential to monitor the identified control measures to ensure that they are operating as required. How to do this is discussed further in Task 5.

As part of the improvement plan, the damaged wall on an existing intake tank (right) is being repaired, and a supplementary intake tank is under construction (left) in Dhaji, Bhutan

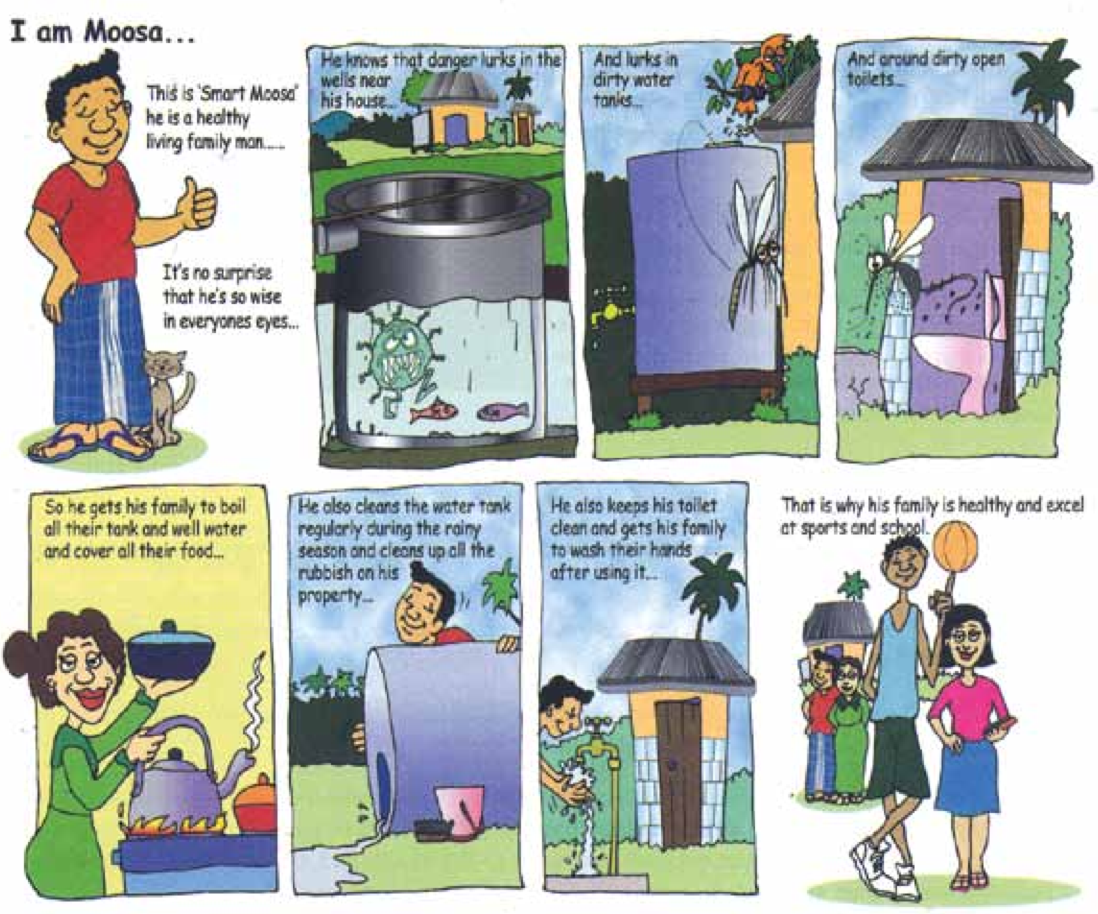
As part of the improvement plan, a water meter is being installed by community members in Australia. Prior to the WSP, the community had no effective means to measure the amount of water they were using.

Look at the pictures and reflect on how many hazards/hazardous events have been minimized through improvements made throughout the water supply system. See the next page for answers.

Spot the differences. Collecting water from a well.

Figures on previous page: What improvements have been made to the water supply system to minimize risks?

1. Covering the well has reduced the risk that bird faeces or other airborne contaminants will reach the water supply.
2. Constructing a fence around the well has reduced the risk of contamination by direct animal access. (Note that wells should be fenced to prevent animal access within 30 metres.)
3. Relocating the livestock pen has reduced the risk that surface runoff containing animal waste will reach the water supply during rain events.
4. Limiting livestock grazing and planting trees uphill of the well have reduced the risk that surface runoff containing animal waste or crop additives/pesticides will reach the water supply.
5. Relocating the latrine to ensure a minimum safe distance from the well has reduced the risk that the water supply will be contaminated by human waste.
6. Placing the animal manure near the farm on a platform instead of directly on the ground has reduced the risk that the water supply will be contaminated by animal waste.
7. Collecting and storing the water in closed containers instead of open containers has reduced the risk that the water will be contaminated during and after collection.



In a practical way, Moosa applies the multiple-barrier approach in this public health cartoon from the Maldives. Household water treatment and safe storage can be an effective barrier if the safety of the water supply is uncertain.

Tips

» Where the WSP team has insufficient information or knowledge, it may choose to seek external advice, particularly for infrastructural improvements or upgrades. Water supply engineers or other experts can help to ensure that improvements are appropriate and sustainable and provide costing information for such improvements.

» When external advice contradicts community-level knowledge, both should be considered. A community that does not accept the opinion of an external expert may not be willing to follow advice. Community members and experts may need to sit down together to share information and discuss the situation to fully appreciate all perspectives.

Outputs:

- Identified control measures to improve drinking-water safety
- An incremental improvement plan, with prioritized control measures and activities
- Decisions on when, where and who for each identified improvement

Task 5 Monitor control measures and verify the effectiveness of the water safety plan

The purpose of Task 5 is to confirm that the community water supply is operating as expected and that the WSP is protecting drinking-water safety and public health.

Operational monitoring: Planned, ongoing observations using checklists for visual on-site inspection and simple water quality measurements to assess whether a community water supply is operating normally—that is, whether the control measures to prevent, remove or reduce contaminants are operating effectively (as planned). Operational monitoring of control measures enables timely detection of operational and water quality problems so that action can be taken prior to the supply of unsafe drinking-water.

Verification monitoring: Verification monitoring confirms that water quality targets or objectives are being achieved and maintained and that the system as a whole is operating safely and the WSP is functioning effectively. It is typically based on compliance monitoring, internal and external auditing of the adequacy of the WSP and adherence to operational activities, and checking consumer satisfaction. In auditing, sanitary inspection formats are often a useful tool for confirming that measures put in place effectively control previously identified risks. The results of verification monitoring are typically included in district, regional or national water supply surveillance programmes.

How to do it

5.1 Establish a monitoring programme

While there are a number of differences between operational monitoring and verification monitoring, they are all simply checks to ensure that the water is safe and the WSP is working effectively. Monitoring programmes should aim to prevent problems and to correct faults in a timely manner. Monitoring should address both preventive (detecting risks so that action may be taken before problems occur) and remedial objectives (identifying problems so that corrective actions can be taken promptly).

Operational monitoring

Quick and easy measurements and observations are best. Examples include observing features during on-site inspections (e.g. the integrity of a fence or wellhead, practices during water collection) and water quality testing for simple indicator parameters (e.g. chlorine residual, turbidity, conductivity). Specific operational monitoring parameters that are appropriate to the local water supply and the control measures being applied should be selected. Related to water quality testing, as a minimum, the following parameters that affect drinking-water quality should be monitored by the operator with support from an external agency if the operator does not have the capacity to monitor water quality: chlorine residual and pH (if chlorination is practised) and turbidity. Operational monitoring is usually done by the person(s) responsible for the day-to-day operation of the community water supply.

For each of the monitoring parameters, the operational limits—limits that will trigger corrective actions—need to be established. Corrective actions aim to bring the control measure back to operating properly—that is, within the set limits. For instance, if the fence around the abstraction area is to be checked weekly, as described in the management procedure, the operational limit is reached when the fence has been damaged. Clearly, that exceedance will initiate corrective action: repair. Similarly, when free chlorine residual at a tapstand falls below a predetermined limit (e.g. 0.2 mg/l), the chlorine dosing will need to be checked and adjusted. Monitoring and corrective actions form the control loop that ensures that unsafe drinking-water is not supplied. Where possible, corrective actions should be specific and prepared and tested ahead of the event to ensure that they can be put in place quickly.

An example of an operational monitoring programme is shown in Table 5.1.

Table 5.1. Example of an operational monitoring programme

Control measure	Monitoring		Operational limit	Corrective action	
Wells are fenced to prevent animal access within 30 metres, and ground is sloped away from wells.	What:	Sanitary integrity of the well and fence.	Integrity of fence or well is compromised per information collected from relevant inspection form.	What:	Repair fence and/or well. Inform land/animal users/owners as appropriate.
	How:	Visual inspection by using inspection form XYZ. Completed form given to WSP team leader for storage and to review trends.		How:	Contact community mechanic and/or plumber and request repair. Call for ad hoc community meeting.
	When:	Monthly.		When:	As soon as identified.
	Where:	On-site at well area.			
	Who:	Community caretaker.		Who:	Community caretaker with mechanic and/or plumber.
Backup generator ensures uninterrupted disinfection during power outages.	What:	Operational reliability of generators.	Dysfunction of generator.	What:	Repair generator.
	How:	Test runs.		How:	Contact community electrician and request checking and repair.
	When:	Quarterly.		When:	As soon as identified.
	Where:	Powerhouse.			
	Who:	Community technician.		Who:	Community technician with electrician.
Chlorine dosing is flow-paced to ensure consistent dosing.	What:	Free chlorine concentration.	Free chlorine concentration is less than 0.2 or greater than 1.5 mg/l.	What:	Take manual water sample and analyse to confirm online chlorine value. If chlorine concentrations confirmed to be correct, follow chlorine non-compliance procedure. Otherwise, check disinfection unit and online analyser for faults and adjust/repair accordingly. If repair of disinfection unit is not possible, use backup device.
	How:	Online chlorine analyser.		How:	Water sampling, testing and analysis according to relevant standard operating procedures. Chlorine non-compliance procedure according to relevant standard operating procedure. Contact community technician and request checking and repair of disinfection unit and online analyser. Check and repair according to manufacturer's manuals.
	When:	Continuously.		When:	As soon as identified.
	Where:	Clear water tank outlet.			
	Who:	Community caretaker for maintenance and calibration of analyser.		Who:	Community caretaker with technician (for repair of online chlorine analyser) and local public health officer (for chlorine non-compliance procedure).
Cover on water storage tank and vermin screening over vent piping.	What:	Integrity of covers and screens.	Integrity of covers or screens is compromised per information collected from relevant inspection form.	What:	Repair/replace cover and/or screen.
	How:	Visual inspection by using inspection form ABC. Completed form given to WSP team leader for storage and to review trends.		How:	Contact community technician and request repair.
	When:	Quarterly.		When:	As soon as identified.
	Where:	On-site at storage tank area.			
	Who:	Community caretaker.		Who:	Community caretaker with technician.

Any sudden change in the local environment (e.g. due to heavy rainfall, at the beginning of the monsoon or during thaw), in river flow or visible water quality (brown, cloudy, turbid water) should trigger increased vigilance, including on operational monitoring.

Examples of factors to be considered when establishing an operational monitoring programme for control measure X

Answering the following questions will help the WSP team develop operational monitoring programmes for control measures and associated schedules:

- Why monitor/perform inspection on X?
- What does monitoring/inspection on X require?
- How will X be monitored/inspected?
- When and where will X be monitored/inspected?
- Who will monitor/inspect X?
- What is the acceptable range of values for X? (Note that this can be a number or qualitative: yes/partial/no!)
- What corrective actions will be taken when X is outside the target range?
- Who will carry out corrective actions?
- What records and reporting of X are required?
- What training is needed for implementation of the operational monitoring programme for X (training for individuals responsible for sampling, testing and analysis)?

Verification monitoring

Verification involves three activities undertaken together to provide evidence that the WSP is working effectively:

1. compliance monitoring;
2. internal and external auditing;
3. checking consumer satisfaction.

Compliance monitoring

Compliance monitoring is typically based on water quality testing for faecal indicator organisms and hazardous chemicals. Typically, the results are checked against established national water quality standards. Compliance monitoring is usually carried out by someone not involved in the day-to-day operation of the water supply, such as a designated and appropriately trained community member or a public health officer/inspector.

Internal and external auditing

Audits help maintain the quality of implementation of a WSP. Audits should involve external review by an independent qualified third party. The external review team may include government officials or the regulatory authority or water quality experts from neighbouring larger utilities. The audit may also involve internal review by people with responsibilities for the operation or oversight of the water supply.

Auditors may identify additional opportunities for improvement, such as areas where planned improvements are impractical, procedures are not being properly followed, resources are insufficient or training or motivational support is required for staff.

It is essential for the auditors to have detailed knowledge of the delivery of drinking-water and to verify information in person through site visits, through interviews with community members responsible for operation of the water supply and by observing the procedures in place. Records may not always be factually correct, and, in some cases, equipment that would appear to be working on paper may not be working in practice.

Examples of factors to be considered when establishing an audit programme

- ✓ Have all feasible hazards and hazardous events been taken into account?
- ✓ Have appropriate control measures been identified for each significant risk?
- ✓ Have appropriate monitoring procedures been established?
- ✓ Have operational limits for control measures been identified?
- ✓ Have corrective actions been identified for control measures that are not working effectively?
- ✓ Have a system and time frame for verification been put in place?

Checking consumer satisfaction

Consumer use of, and satisfaction with, the water supply is an important indicator of whether the water supply is operating effectively. Consumer complaints about taste, colour or odour should raise concern that the drinking-water may not be safe. On the other hand, water that tastes or smells strange or does not look "clean" may not be accepted by the community, even though it is perfectly safe. This may lead consumers to use other, less safe water.

Any complaints about taste, colour or odour should raise concern and be investigated.

5.2 Record and share results

All operational monitoring and verification data should be documented, filed and shared with relevant stakeholders. There may be legal or other requirements to submit reports to public health or regulatory officials. The WSP team should check to see who needs to receive this information. If there is no mandatory reporting, the WSP team should consider who would benefit from receiving these reports.

5.3 Frequently assess results

Water quality monitoring and sanitary inspection data should be regularly reviewed to confirm that control measures continue to work and allow for adjustments to stay within operational limits. For instance, the output of a slow sand filter will decline over time when clogging of the filter increases. This information tells the operator when he or she may have to take the filter out of operation for cleaning, at which time the operator will simultaneously have to provide for extra water storage to tide consumers over the cleaning break and inform them to use water sparingly for a few days. Monitoring and audit programmes should aim to prevent problems and to correct faults in a timely manner.

Over time, this documentation will be helpful, as results are analysed, to explain historical performance and occurrences and to show what risks occur with what frequency. This information will help to improve the continued implementation of the WSP, especially to justify investments.

Task 1
Task 2
Task 3
Task 4
Task 5
Task 6

Case-study: The New Zealand approach to health risk management in rural water supplies

Cartoon information material for the New Zealand Public Health Risk Management Plan

In rural areas of New Zealand, people take water from small piped supplies or from home-based systems such as wells and rainwater harvesting. Many small rural New Zealand communities and homes may not always have access to safe drinking-water. As a result, the Ministry of Health of New Zealand has, in the last decade, undertaken a programme to support small communities to ensure water safety. Various materials have been developed to promote the understanding of water safety, such that communities can work towards compliance with the Drinking-water Standards for New Zealand by preparing, using and updating a Public Health Risk Management Plan (PHRMP, the local name for a WSP). Checklists and information materials have been prepared, including cartoons, from which a still picture is shown here (New Zealand Ministry of Health, 2006).

An excerpt from the New Zealand Public Health Risk Management Kit (New Zealand Ministry of Health, 2008) is shown below:

Having your PHRMP approved

Send your completed PHRMP to a Drinking-Water Assessor (DWA) at the local District Health Board for approval. Check you have included the following information in your PHRMP.

Have you included?	Tick if included
Organisation details, including owner, contact details and supply name?	
A flow chart and/or schematic and/or photos to **describe your supply** from catchment to distribution?	
An assessment from catchment to distribution that identifies what could cause the water to become unsafe to drink, what could be done about it and **prioritises what needs attention**?	
An **improvement plan to manage what needs attention,** giving priority to areas of greatest concern and things that can be easily fixed, including timeframes and estimated costs?	
A **monitoring and inspection plan** that indicates when the water is becoming unsafe?	
Emergency and incident plans that describe what action will be taken if things go wrong in the meantime?	

The Drinking Water Assessor will assess your PHRMP and return it to you with a report within 20 working days. They may visit your supply periodically to see your progress in using your PHRMP.

For further information please contact either your Drinking Water Assessor or Technical Assistance Programme (TAP) Facilitator at the local District Health Board, or your Environmental Health Officer at your local council.

Information on submitting a Public Health Risk Management Plan to the local district health board in New Zealand

Tips

» Operational monitoring, compliance monitoring and auditing may be mandatory, such as when required by regulations. In these cases, the responsible authorities are likely to give specific direction. Where the community has insufficient resources and/or capacity to meet the regulatory requirements (or to create operational monitoring programmes when there is no regulatory requirement), the WSP team should engage appropriate authorities and experts to provide advice, guidance and assistance. These stakeholders may additionally be able to provide or leverage free or subsidized water quality testing services.

» The WSP team must continually review the needs of the monitoring programme in light of newly identified risks that may contaminate drinking-water supplies. For example, new risks could come from industries, agricultural activities or human settlements established around the drinking-water source that were not present or identified when the WSP or monitoring programme was originally designed.

» Changes to monitoring results outside of normal ranges from regular inspections and/or monitoring are an indication that risks may have changed. The WSP team may then need to review the situation, modify the WSP and implement improvements.

» Small supplies may find it helpful to partner with another community water supply or water utility to audit each other's WSPs, to help ensure that each WSP is comprehensive and effective.

Outputs:

- Monitoring schedule to assess the continued effectiveness of existing control measures, corrective actions and improvements at appropriate intervals
- Evidence that the WSP is working effectively
- Measurement of progress towards, or meeting, the water quality targets or objectives
- Confirmation that interventions are appropriate for the risks identified

Task 6 Document, review and improve all aspects of water safety plan implementation

The purpose of Task 6 is to document the status and the level of operation and management of the water supply system and to ensure that the WSP approach is embedded in operations and that the WSP remains up to date and effective.

How to do it

6.1 Document management procedures

Good information on the status of and procedures for running the water supply is essential for effective management and planning. The development of the WSP will have yielded a lot of information, for example, on the origin of the system, its design and construction, or ownership details of land on which a reservoir or a hand pump was built. It is very important to retain copies of the documentation and to know where the original files are to be found (e.g. at the district water office or the land registry).

Management procedures:
Written instructions describing steps or actions to be taken during normal operating conditions and for corrective actions when operational monitoring parameters reach or breach operational limits. These are often called "standard operating procedures" or SOPs. Additionally, emergency management procedures should be developed for any unforeseen events or deviations that may occur.

All systems require instructions on how to operate. Management procedures (e.g. standard operating procedures) and manuals should be available for individual technical components of the system, such as for a hand pump or diesel generator. Some procedures also need to be tailor-made to reflect the actual situation. It is important to have relevant information available and properly stored.

Documenting operating, maintenance and inspection procedures is important because it:

- helps build confidence that operators and backup support know what to do and when;
- supports consistent and effective performance of tasks;
- captures knowledge and experience that may otherwise be lost when community members have moved;
- helps reinforce the importance of the role of the community in the water supply system;
- helps in training and competency development of new community operators;
- forms a basis for continuous improvement.

Diesel generator in Magala Adi village, Somali National Regional State, Ethiopia, with caretakers. The village enjoys borehole water from several tapstands at 20 Birr cents a bucket. The next nearest water point is 9 kilometres away, on foot!

In addition to the technical information needed to run the system, management procedures should be developed outlining the tasks to be undertaken in managing all aspects of the water supply, including during emergency situations. The WSP is an important source of information for drafting these management procedures. The WSP team also needs to ensure that the different roles and responsibilities (i.e. who does what, when, where, how and why) for water safety are clearly understood by everyone involved. An efficient, regular review and updating cycle is important.

Also, procedures for routine monitoring and inspection activities and their collected results (see Task 5) are obviously also important management information and need to be documented.

As a minimum, the WSP team should document management procedures for the items included in Table 6.1.

Table 6.1. Examples of management procedures to be documented for a community water supply system

Catchment/abstraction	Treatment	Storage and distribution	User installations
Land use zoning and management plans. Procedures and forms to monitor/ inspect activities in the catchment area (e.g. agricultural practices, such as fertilizer application). Maintenance, cleaning and inspection schedules and procedures for abstraction infrastructure. Schedules and procedures to monitor raw water quality. Procedures for notifying source water users (including downstream users) during incidents or accidents in the catchment/source water(s).	Operation and maintenance schedules and procedures for all aspects of the treatment cycle of the system (e.g. aeration, filtration, chlorination). It may be useful to post these procedures on the wall of the treatment plant for easy access. Operational monitoring procedures to confirm the effectiveness of treatment processes (e.g. for turbidity and chlorine levels).	Maintenance, cleaning and inspection schedules and procedures for storage tanks and pipelines. Procedures for (factories filling) bottled water and filling stations of tankers conveying drinking-water, if relevant.	Public information and education plans. Procedures for notifying customers (e.g. boil water alert). Procedures for responding to and investigating consumer complaints about taste or odour.
	Schedules and procedures to monitor drinking-water quality (compliance monitoring).		

Additional information to be recorded, collected and stored for easy retrieval includes the following:

- accurate and accessible system information (e.g. location of abstraction points and distribution system, including tanks, valves, pumps, washouts, etc., construction materials used, age of infrastructure);
- operational roles and responsibilities;
- contact details for operators and caretakers (with mobile phone numbers if available);
- contact details for water equipment suppliers;
- training programmes for operators, contractors and water committee members;
- design standards for infrastructure;
- relevant plumbing codes and standards and enforcement procedures;
- compliance monitoring results; copies of results shared with public health and water supply regulatory authority (as required by regulation);
- audits, inspections and security check programmes;
- programme for reviewing/revising documentation;
- annual reports/financial statements;
- documentation on periodic review and revision/amendment of the WSP.

Case-study: Recovering system information in Zanzibar town

Water shortage and poor water quality in Zanzibar town was caused by an aged and poorly maintained water supply system, rapid urban expansion, limited natural supply sources and the degradation of watersheds (DWD & Finnida, 1994). In 1993, when the Directorate for Water Development of Zanzibar wanted to improve services in Zanzibar town, a big problem was that it no longer knew where the pipelines and connections were, as these had been poorly recorded, if at all. Rehiring retired linesmen and plumbers helped a great deal to recover the information on the assets of the distribution system. This experience demonstrates the importance of documenting system information and worker knowledge so that it is not lost over time.

It is important for the operating and maintenance procedures to be documented in the form of directions, based on an understanding of what actions are appropriate under different circumstances. People operating the system must accept responsibility and clearly apply water safety principles and practices to ensure the best protection for the community.

The WSP team should develop incident/emergency management procedures for unforeseen events to help the community respond to possible risks to public health. There is a continuum of operations, from normal to events, to incidents, to emergencies and, finally, to disasters. Providing safe water is critical, and the water needs to be restored as soon as possible during any event or incident. If the safety of water is in doubt under any circumstance, operators must notify consumers and either issue a drinking-water advisory (if appropriate) or provide an alternative water supply. Many countries are developing or have emergency response plans in place that provide important recommendations, including on household water treatment and safe storage. In addition to consulting these plans or getting in touch with the relevant authorities, identifying best practices related to the use of household water treatment and safe storage during emergency situations may be helpful in developing locally relevant safe water solutions during emergencies (WHO/UNICEF, 2011).

Following any emergency, incident or near-miss, the community and operators should learn as much as possible from the event to improve preparedness and to plan for future emergencies (see 6.3 for further details). Reviewing the emergency management procedures may require some changes to the existing plan.

Examples of key areas to be included in emergency management procedures

- Response actions to potential public health risks, including, among others, increased monitoring and inspections, boil water advisories or restricted water use advisories
- Roles and responsibilities for all involved stakeholders, including contact details
- Plans for emergency water supplies
- Protocols and plans for communication, including community notices (within the community, public health professionals, regulatory body, media and the public), with special attention for proper notification of the public and high-risk groups
- Mechanisms for increased public health surveillance

6.2 Participate in supporting activities

Supporting activities are important in ensuring water safety, even though they may not affect water quality directly. They incorporate the principles of good management that underpin the WSP. Codes of good operating, management and hygienic practices are essential elements in this respect. These are often standard operating procedures or system operating rules.

Water suppliers or their associations will ordinarily have supporting activities in place as part of their normal operations. For most, the implementation of supporting activities will involve collating existing operational and management practices, initial and periodic review and updating to continually improve practices, promoting good practices to encourage their use and auditing practices to check that they are being used, including taking corrective actions, where necessary.

Supporting programmes can include, but are not limited to:

- training programmes for personnel involved in the water supply;
- tools for managing the actions of staff, such as quality assurance systems;
- education of community members whose activities may influence water quality;
- communication protocols to ensure that there is a clear and defined pathway for communicating information;
- mechanisms for tracking consumer complaints and actions taken to respond to complaints;
- calibration of monitoring equipment;
- record keeping.

Where supporting activities do not exist, small community water supplies can make an effort to establish and implement their own programme support activities, including training and educating appropriate staff and community members, potentially by collaborating with government officials, local or regional NGOs, associations of water user committees, local training institutions and other small communities. The WSP team should contact these organizations for help and guidance in identifying suitable supporting activities. Regardless of how sophisticated national and regional policies and programmes may be, experts from these organizations should, at a minimum, be available and willing to provide assistance and guidance, even if only on an advisory or ad hoc basis. Experts could include inspectors, public health professionals, water quality experts and water resource specialists. Ideally, these experts would be able to bring to the team's attention, and help leverage, tools such as grant schemes and inspection forms.

Case-study: Government support in Bhutan

In Bhutan, the national WSP team prepared WSP templates for the Ministry of Health. These templates were shared with the district-level local government engineering departments that, together with the health sector, are responsible for assisting communities to develop and operate their water supply systems. The templates serve as a starting point for all village water supplies in the districts.

The government in Bhutan provides technical support for water supply to communities

6.3 Regularly review the WSP

Periodically, the team should meet to review the WSP and to learn from experiences and new procedures. The WSP should also be reviewed whenever there are significant changes in or around the community water supply, including recent land use changes. The review process is essential to overall implementation and provides the basis from which future assessments can be made. Periodic reviews are particularly important in small community water supplies where capacity is limited and where the objective is to make incremental improvements over time to achieve national, state and community-based water quality targets or objectives.

To review the plan, the team should return to Task 1 (Engage the community and assemble a WSP team) and work through it again. The team should then move through the other tasks again in order. As the team is not starting from scratch, and assuming that the initial process was well documented, the tasks should be easier and take less time to complete.

During the review, it may be helpful to:

Shisuwa Badahare, Nepal, original layout plan used to develop the WSP

- review and include any new activities or changes in the catchment area, abstraction, treatment, storage, distribution and consumer components of the water supply, as applicable. This includes reviewing and updating the water supply description and map/schematics as needed. New hazards and associated risks should be incorporated, and previously identified risks should be updated with additional or new information. The original layout plan shown to the right, for example, will need to be updated to incorporate any new activities or changes that have occurred in the water supply since the WSP was first developed.
- review the improvement schedule. This will need to be updated as improvements are completed. New information or resources may mean changing the order of priority for the improvements.
- review the roles and responsibilities and standard operating procedures. Have the roles and responsibilities of management or staff changed since the last review? Have there been personnel changes since the last review? Have there been any changes in system operation, maintenance, inspection and monitoring processes and procedures?
- review available water quality data and any completed sanitary inspection forms. Are control measures working as planned? Does the risk assessment need to be updated based on these results?

The WSP should additionally be reviewed following an emergency an incident, or a near-miss. During this review, the team should consider the following questions:

- What was the cause of the problem?
- How was the problem first identified or recognized?
- What were the essential actions required, and were these carried out?
- What communication problems arose, and how were they addressed?
- What were the immediate and longer-term consequences?
- How well did the emergency procedures function?
- Have these hazardous events highlighted any weaknesses in the WSP, and how can the team (or the local government) prevent a recurrence of the problem causing the emergency?
- Has the WSP been updated to reflect the lessons learnt to avoid a similar problem in the future?

Tips

- Consider checking with local government, water supply associations and NGOs for continued training opportunities for operators, plumbers, pump drivers and community-based maintenance workers, to ensure upgrading of skills and timely replacement of staff.
- Various forms of mass media can be used to raise the effectiveness of communication on the WSP in all types of communities. Often posters with pictures and diagrams, discussions on the local radio and, of course, public meetings are useful to brief consumers. The WSP team should consider how to use information, education and communication formats and consumer relations in the most effective ways to ensure good interaction between the community and the operators or water user committee.
- Where a community has low literacy levels, pictures and diagrams can be used to communicate and document management procedures to all involved in operating and managing the community water supply.
- Following an emergency, an incident or a near-miss, risks should always be reassessed. The WSP team may need to modify the incremental improvement plan.
- The team may also want to review the process for developing and implementing the WSP. As mentioned previously, there is no one-size-fits-all approach to WSPs; hence, each community may need to try its approach and then review it to ensure that public health is being protected.
- Following the review, the WSP team should ensure that all documentation and contact lists are up to date and that all staff and operators are informed about the updated version. A new date for the next review process should also be scheduled.

Outputs:

- Well-established record-keeping and documentation system, with transparent communication procedures
- Management procedures for standard (normal) and emergency situations, shared with all members of the WSP team and operators responsible for managing the community water supply
- List of supporting activities needed and available
- Participation in or establishment of supporting activities
- Documented WSP and a method to review the WSP periodically
- Incremental improvements made over time to achieve national, state and community-based water quality targets or objectives

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The photographs and figures used in this manual are from the following sources:

Cover: David Sutherland. *Water safety plan team members examining protected area around storage tanks supplying piped water to Shisuwa Badahare, Nepal; storage tank in Shisuwa Badahare, Nepal; tapstand in Kavre, Nepal; community meeting to discuss the water safety plan in Kavre, Nepal, August 2009.*

Page 1: Han Heijnen. *Village health team members discussing hepatitis E prevention through use of a safe water chain in Akwach sub-county, Uganda, 2009.*

Page 2: 1. Maria Campos; 2. Shinee Enkhtsetseg; 3. Safo Kalandarov. *Examples of small community water supplies in 1. Puno, Peru; 2. Dusheti district, Georgia; and 3. Qaraghoch, Tajikistan.*

Page 3: Colette Robertson-Kellie. *Small community water supply in Scotland.*

Page 3: 1. Donald Reid; 2. Oliver Schmoll; 3. María Gunnarsdóttir. *Examples of small community water supplies in 1. Manitoba, Canada; 2. Ethiopia; and 3. Dalvik, Iceland.*

Page 4: David Sutherland. *WSP team members learning how to measure conductivity in drinking-water in Talas, Kyrgyzstan.*

Page 5: RWSSFDB (2006). *It is important to assess the water supply system together and collect the critical information needed to develop a WSP.*

Page 8: Bettina Rickert. *Meeting with community members in Pendzhekent district, Tajikistan.*

Page 8: Han Heijnen. *Corner meeting in Tharpu, Nepal.*

Page 9: Han Heijnen. *Chairman, accountant and plumber of the Anbukhaireni WSP scheme committee in Tanhu district, Nepal, in front of the scheme map including 600 household connections, made as part of the development of a WSP.*

Page 12: Han Heijnen. *Mapping the community water points in a community in northern Nigeria.*

Page 13: Redrawn from Live & Learn Environmental Education (2008). *Water supply system in Mele, Efate, Vanuatu.*

Page 15: Han Heijnen. *Discussing the results of community mapping of water points in Baganbari slum, Dhaka, Bangladesh.*

Page 17: Han Heijnen. *Recent road construction exposed a section of buried mains high-density polyethylene pipeline for a water supply system in Nepal.*

Page 19: Bettina Rickert. *An unprotected public water collection point in Fayzabad district, Tajikistan.*

Page 21: Based on WHO (1997). *Example of a sanitary inspection form and risk score for rainwater collection and storage.*

Page 22: Sinead Tuite. *In the Northern Karamoja region in Uganda, this hand pump enclosure is opened in the morning and in the afternoon by an elder who also supervises the collection of the water.*

Page 27: Fraser Thomas Ltd & Lanka Rain Water Harvesting Forum (2006). *The shallow well is quite close to the toilet, raising the risk of contamination.*

Page 27: Fraser Thomas Ltd & Lanka Rain Water Harvesting Forum (2006). *Runoff of pesticide, fertilizer or manure may be a risk in many rural areas.*

Page 27: Colette Robertson-Kellie. *Unprotected well in Scotland that has since been improved!*

Page 27: Bettina Rickert. *Protected well in the Federal State of Schleswig-Holstein in Germany.*

Page 30: Han Heijnen. *Washing vehicles in Kireka, Uganda.*

Page 33: Angella Rinehold. *As part of the improvement plan, the damaged wall on an existing intake tank is being repaired, and a supplementary intake tank is under construction in Dhaji, Bhutan.*

Page 33: Robyn Grey-Gardner. *As part of the improvement plan, a water meter is being installed by community members in Australia.*

Page 34: Möller & Samwell (2009). *Spot the differences.*

Page 35: Live & Learn Environmental Education (2006). *In a practical way, Moosa applies the multiple-barrier approach in this public health cartoon from the Maldives.*

Page 41: New Zealand Ministry of Health (2006). *Cartoon information material for the New Zealand Public Health Risk Management Plan.*

Page 41: New Zealand Ministry of Health (2008). *Information on submitting a Public Health Risk Management Plan to the local district health board in New Zealand.*

Page 43: Han Heijnen. *Diesel generator in Magala Adi village, Somali National Regional State, Ethiopia, with caretakers.*

Page 46: WHO Regional Office for South-East Asia/WHO Regional Office for the Western Pacific. *The government in Bhutan provides technical support for water supply to communities.*

Page 47: Han Heijnen. *Shisuwa Badahare, Nepal, original layout plan used to develop the WSP.*

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[1] The web links given in this section were current as of December 2011.

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Suggested web sites

Household water treatment and safe storage (World Health Organization): http://www.who.int/household_water/en/

Model water safety plans for various water supply types (International Training Network Centre, Bangladesh University of Engineering and Technology): http://www.buet.ac.bd/itn/pages/outcomes/wsp.html

Risk assessment templates and other WSP-related resources for private water supplies (Government of the United Kingdom): http://www.privatewatersupplies.gov.uk/private_water/22.html

Small community water supply management (World Health Organization): http://www.who.int/water_sanitation_health/dwq/smallcommunity/en/index.html

World Health Organization/International Water Association Water Safety Portal (includes case-studies, tools and other information on water safety plans: http://www.wsportal.org

Glossary

Audit: Audits help in the implementation of a water safety plan by ensuring that water quality and risks are being controlled effectively. Audits should involve external review by an independent qualified third party and may also involve internal review by people with responsibilities for operating or overseeing the water supply. Auditing can have both an assessment and compliance-checking role and should be undertaken regularly.

Catchment: The catchment, or drainage basin, is a discrete area of land that has a common drainage system. A catchment includes both the water bodies that convey the water and the land surface from which water drains into these bodies.

Community water supply: The system(s) used by the community to collect, treat, store and distribute drinking-water from source to consumer. The definition of a small community water supply can vary widely within and between countries. However, it is the operating and management challenges they face that most commonly set small community water supplies apart.

Control measures (also referred to as barriers or mitigation measures): Activities and processes that can be used to prevent, eliminate or significantly reduce the occurrence of a water safety hazard.

Corrective action: Any action to be taken when the results of monitoring at a control point indicate a loss of control (e.g. when operational limits are exceeded).

Flow diagram: A systematic representation of the sequence of steps or operations used in the production or manufacture of a particular water item.

Hazard: A biological, chemical, physical or radiological agent that can cause harm to public health.

Hazardous event: An incident or situation that introduces or amplifies a hazard to, or fails to remove a hazard from, the water supply.

Management procedures: Written instructions describing steps or actions to be taken during normal operating conditions, for corrective actions when operational monitoring parameters reach or breach operational limits and for unforeseen, emergency events or deviations that may occur.

Mapping: The process of gathering information about a community water supply by having its members create their own map. Community members can draw the map on a sheet of paper; specialized equipment and/or skills are not necessary. However, maps should be sufficiently detailed to easily identify hazards and risks to the water supply.

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

Operational limit: Defined limit set for operational acceptability of control measures.

Operational monitoring: Planned, ongoing observations using checklists for visual on-site inspection and simple water quality measurements to assess whether a community water supply is operating normally—that is, whether the control measures to prevent, remove or reduce contaminants are operating effectively (as planned).

Participatory rural appraisal: A rapid and inexpensive assessment of the most important features of the living conditions of an urban or rural population. The assessment is done primarily by an interdisciplinary team (including at least one sociologist) and takes place in the field. Participatory rural appraisal is designed as an ongoing learning process for both local and external participants.

Pocket chart: A very effective method to collect information about people's perceptions, habits, desires and will. It provides quantitatively valid information by a system of voting and further enables discussions with community members.

Risk: The likelihood of a hazard causing harm to exposed populations in a specific time frame and the magnitude and/or consequences of that harm.

Sanitary inspection: An on-site inspection and evaluation by qualified individuals of all conditions, devices and practices in the water supply system that pose an actual or potential danger to the health and well-being of the consumer. It is a fact-finding activity that should identify system deficiencies—not only sources of actual contamination, but also inadequacies and lack of integrity in the system that could lead to contamination.

Transect walks: Systematic walks with key informants through the area of interest, while observing, asking, listening and seeking out problems and solutions. There are different types of transects—walking across an area, looping, walking from one water point to another and so on. Walking through a community leads to an understanding of the power divisions, environmental sanitation and construction quality, among other issues. Transect walks are frequently used in water and sanitation programmes.

Verification monitoring: Verification monitoring confirms that water quality targets or objectives are being achieved and maintained and that the system as a whole is operating safely and the water safety plan is functioning effectively. It is typically based on compliance monitoring, internal and external auditing of the adequacy of the water safety plan and adherence to operational activities, and checking consumer satisfaction.

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

World Health Organization

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