A Conceptual Framework to Evaluate the Impacts of Water Safety Plans

Centers for Disease Control and Prevention
4770 Buford Highway NE (F-60)
Atlanta, GA 30341

1.0 Introduction

According to the World Health Organization (WHO) Guidelines for Drinking-water Quality, “The most effective means of consistently ensuring the safety of a drinking-water supply is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer. In these guidelines, such approaches are called water safety plans (WSPs)” (WHO, 2006). The WHO Guidelines also place WSPs within a larger “framework for safe drinking-water” that includes the public health context and health outcomes and also contains health-based targets and drinking water surveillance (Fig 1). As such, WSPs are specifically linked to health, with an implicit expectation that implementation of WSPs will safeguard health in areas with acceptable drinking water quality and improve health in areas with poor drinking water quality.

At a certain level, this expectation of a link between WSPs and health can be taken at face value; ever since John Snow removed the handle of the Broad Street pump, which halted the London cholera outbreak of 1854, there has been a well recognized link between drinking water safety and health (Paneth, 2004). However, the link between a WSP undertaken for an existing piped drinking water system and ultimate health outcomes is not as direct as that between the Broad Street water pump and cholera. Unlike the Broad Street pump, many systems, even prior to WSP initiation, already have multiple barriers between sources of contamination and consumers. Such barriers may include source protection, water treatment with residual disinfection, safe storage, and a distribution system that prevents recontamination of treated water. The multiple barrier approach aims to employ as many of these barriers as necessary so that a failure in one area does not immediately expose consumers to unsafe water. For example, providing a residual disinfectant may counter the effects of leaks in the distribution system that could lead to recontamination after treatment.

Therefore, many intervening factors can come between implementation of an individual WSP and ultimate health outcomes. Some examples may include operational factors such as continuity of service, or institutional factors such as better training for employees that results in improved protection of water safety. Evaluating the impacts of a WSP, therefore, requires a much broader analysis than simply looking at health improvements. Just as WSPs are placed into a larger “framework for safe drinking-water” in the WHO drinking water guidelines, the impacts of WSPs must also be placed into a larger context beyond simply health. This paper outlines a conceptual framework for conducting this type of overall evaluation of the impacts of a WSP. Drawing examples from existing WSPs in various regions, the framework also illustrates the types of intermediate outcomes that can be expected during WSP implementation.

The purposes of this framework to evaluate WSP impacts include the following:

- Elucidate the varied outcomes and impacts of WSPs beyond simply health impacts
- Provide a common framework and terminology for defining WSP outcomes and impacts
- Provide information for WSP implementers on the different types of outcomes to expect
- Provide a basis for development of indicators to measure WSP outcomes and impacts
- Provide a common understanding of the time frames within which various WSP impacts may occur
- Illustrate the various benefits of implementing WSPs, even when no direct health impacts are immediately apparent at the individual project level
- Help to establish a strong evidence base for the effectiveness of WSPs, to enable scaling up of WSP implementation.

This conceptual framework is designed to be one of a set of tools to guide the implementation and evaluation of Water Safety Plans, along with the WHO guidelines (WHO, 2006), the Water Safety Plan Manual (Bartram et al, 2009) and other tools and resources developed for national or regional use[1]. The framework should therefore be used for the specific purposes above, and as a complement to these other tools rather than as a standalone instrument. It is not an introduction to WSPs for those without experience in WSP implementation and presumes some level of familiarity with WSPs.

[1] Many of these tools and resources are included in the Water Safety Portal (WSPortal.org), an internet site dedicated to collecting and disseminating information about WSP implementation.

2.0 Structure of the Conceptual Framework to Evaluate WSP Impacts

This conceptual framework for evaluating WSP impacts uses a logic model structure. Logic models are "graphic depictions of the relationship between a program's activities and its intended outcomes" (USDHHS, 2005). Logic models may also be referred to by other terms, such as program theory or program roadmap but refer to the same type of graphic illustration of a program's activities and outcomes.

Although logic models can vary in structure, they often contain the following basic elements, as shown in Figure 2 (USDHHS, 2005; W.K. Kellogg Foundation, 1998):

- Inputs: resources available to a program (including human, financial, organizational, and community resources)
- Activities: what a program does with the above inputs (processes, tools, actions)
- Outputs: direct products of program activities
- Outcomes: intermediate changes resulting from a program's activities and outputs, sometimes divided into short and longer term outcomes (changes in behavior, knowledge, skills, status and level of functioning)
- Impacts: ultimate change as a result of program activities

Drawing examples from existing WSPs, this framework places WSPs into a larger context that includes these elements of a logic model[2]. Figure 3 shows the WSP Conceptual Framework. Individual elements of this framework are discussed in further detail below. The majority of this discussion is concentrated on outcomes and impacts, as those are the focus of this paper.

This conceptual framework also contains a time element, to illustrate how different WSP outcomes and impacts become apparent at different points in time. For example, longer term effects such as improvements in health will not be apparent during the output phase when the WSP is being developed, or even in the outcome phase when the first effects become apparent.

[2] Selected examples are used to illustrate outcomes and impacts that have been seen from implementation of WSPs in various regions but this paper is not a comprehensive literature review of WSP impacts.

It is important to keep in mind that although a logic model can help to clarify how a program is intended to work, it does not necessarily represent "reality at any point in time" (USDHHS, 2005). Especially for a relatively new program, such as the global implementation of WSPs, where all of the intended outcomes and impacts may not yet be apparent, the logic model represents a hypothesis about those results, and may change as more information about results becomes available.

It is also important to note that the process of undertaking a WSP and any subsequent outcomes and impacts from that process is not a linear one. Figure 3 necessarily represents a simplified schematic of what can happen during this process and variations will obviously occur. In addition, feedback and interactions between the elements (as shown in Figure 3) will occur and influence the process as well.

2.1 Inputs

Inputs are the human, financial, organizational, and community resources available to a program to implement activities. Since a WSP is designed to be a stakeholder based process, one of the primary resources is the institutional partners involved in the WSP process. Those partners can include the obvious and expected ones such as the water supplier, regulatory and permitting agencies (often the Ministry of Health, for example), and organizations with responsibility for watershed or recharge areas, such as agriculture or forestry agencies. However, they should also include other less traditional partners, such as consumers or consumer groups, private industries working in watershed or recharge areas and local government entities. Amongst the stakeholders, the water supplier is "first among equals" in terms of partners and typically takes a lead role in implementing a WSP. Although other stakeholders are often critical to the process and its success, the involvement and commitment of the water supplier is a *sine qua non* for a successful WSP.

Beyond the institutions involved in WSP implementation, individuals also often play a large role in ensuring the success of a WSP. Such "champions" often help in initiating and organizing the WSP process and also motivate other partners to get or stay involved. WSP champions can come from any of the institutional partners mentioned above and are not always necessarily within the water supplier.

In order to successfully implement a WSP, the stakeholders have to provide specific resources such as time commitment of staff, facilities to hold meetings or workshops, and materials and equipment for those events, all of which represent inputs. In addition, knowledge is an input provided by the stakeholders, as the WSP process typically draws heavily on existing information and experience. Providing these resources demonstrates a level of political will and motivation to support the WSP, which is also considered an input on the part of the stakeholders and management (Summerill, in press). Although motivation is an input at the very beginning of the WSP process, it remains crucial throughout the process. This is especially true in the transition from outputs to outcomes, where recommendations from the WSP are actually implemented, resulting in positive changes. Without continuing motivation, the WSP can become an exercise in report writing that stops at the output phase when the initial WSP document is finished, never achieving the WSP's full potential for change.

Funds for WSP implementation can come from stakeholders themselves or from outside entities. In the case of many pilot or demonstration WSP projects in various regions around the globe, initial funding has been provided by outside organizations with an interest in improving drinking water supplies and public health.

Assessing inputs can help in gauging the level of commitment to the WSP. If an organization assigns limited staff with little knowledge to WSP tasks, it may be a sign of limited commitment to the process, which could affect the ultimate success of the WSP (Zimmer et al, 2007).

2.2 Activities and Outputs

Logic models often distinguish between the activities of a program and program outputs, or the products the program produces. However, for the purposes of this conceptual framework for evaluating WSP impacts, the WSP itself is considered both the program activity and program output (see Figure 3). Thus, the WSP is both what the program does (an activity) and the product of the program activity (an output). Using the inputs described above, the program undertakes the *process* of a WSP, an activity involving steps such as forming a WSP team, developing a water system description, assessing risks for that system, identifying control measures to manage those risks and implementing and verifying those corrective actions (Bartram et al, 2009). At the same time, the *product* of the WSP process is the WSP document itself, which represents an output[3]. Thus an activity within the WSP may be the convening of stakeholder meetings or workshops to accomplish specific tasks such as prioritizing risks or developing recommendations to manage those risks. The concrete products that result from those meetings, like the WSP system description or list of hazardous events represent components of the final output, which is the WSP document itself. These WSP outputs (including the WSP document itself) are products of program activities, and represent valuable steps towards improving drinking water safety. However, although these outputs provide the foundation for change, they do not yet represent change; and additional steps are required to actually improve drinking water safety. These changes represent *outcomes* and are discussed in the next section.

2.3 Outcomes

The outcomes from a WSP are the intermediate changes that result from the WSP process. Whereas products such as the WSP document represent outputs, an outcome occurs when there is a change that results from a WSP. Continued motivation and commitment is needed to carry the WSP outputs discussed above through to outcomes that can actually improve drinking water safety. Outcomes such as better communication between WSP stakeholders typically become apparent before impacts such as improvements in water supply and health. Although these outcomes are not specifically health-related, they still provide benefits to many of the stakeholders in the WSP process, and ultimately help to lead to improvements in water supplies and health.

WSP outcomes can be quite diverse, and this framework classifies these outcomes into four categories: institutional, operational, financial and policy changes. Examples drawn from WSP case studies are used to illustrate each type of outcome. As shown in Figure 3, these different outcomes typically occur at different time scales, with institutional changes often being the first ones to become apparent, followed by operational and financial changes, and, ultimately, policy changes. In addition to detailed explanations of these outcomes in the text below, detailed figures are also presented for each of these categories of outcomes, which highlight specific case

[3] Although the WSP is an output, it should not be a static one, as the WSP process is designed to be iterative, producing a continuously updated WSP product (see Modules 10 and 11 in WHO, 2009).

study examples (figures 4-7). The case studies represent a spectrum of situations, from small community water systems in rural Bangladesh to a large urban water system in Australia. (see Table 1 for summary descriptions of the case studies included here). These specific WSPs are not intended to be representative of every WSP, but they do provide illustrations of common themes among the types of outcomes from a WSP.

2.3.1 Outcomes: Institutional Change

Institutional changes are typically the first outcomes resulting from the WSP process. Many of these institutional changes occur within the water supplier, but they occur in other stakeholders involved in the WSP process as well. In the six WSP case studies, these institutional outcomes were observed to fall into four areas: increased communication and collaboration, increased knowledge and understanding, improved perceptions and attitudes, and increased training (Figure 4). Each of these institutional outcomes is discussed below, with reference to specific case studies.

Increased Communication and Collaboration

Increased communication and collaboration among stakeholders may be one of the most important initial outcomes from the WSP process. By catalyzing better communication and collaboration, WSPs may help to produce effective action steps toward improving drinking water safety. For example, in Guyana, the WSP process brought together various stakeholders, including the water supplier and the Ministry of Health, which is the drinking water regulator. A representative of the water utility stated that the WSP process had greatly improved relations and communications with the regulator, leading to better coordination of efforts to improve drinking water safety, such as monitoring of water quality in the distribution network (Gelting, 2008, unpublished).

Increased Knowledge and Understanding

An increase in knowledge about and understanding of the drinking water system among water supplier staff and other stakeholders often naturally occurs over the course of the WSP process. When staff are encouraged to collaborate and take an active role in the WSP development process, an increase in understanding of the water system is often observed. In

South Africa and Bangladesh, due to increased understanding of all parts of the water supply system, operators were observed to have an improved ability to prevent and resolve water quality issues on their own after WSP implementation. This, in turn, encouraged staff to share their knowledge with others in the utility, in order to further increase understanding among less-knowledgeable staff (Mahmud et al, 2007; Rand Water, 2007).

Improved Perceptions and Attitudes

As discussed above, the WSP process can help create a positive environment of good communication, collaboration and understanding, where staff feel more competent and recognized for their work. This environment can, in turn, lead to improvements in staff perceptions and attitudes toward their roles and responsibilities (Summerill et al, 2010). When these other institutional outcomes are in place, staff become more willing to acknowledge and embrace change resulting from the WSP. Initially water provider staff may be hesitant of the WSP process, as it often calls for changes in procedures and terminology that have been in use for extended periods of time (Howard et al, 2005; Rand Water, 2007). However, in South Africa, the water provider found that active participation and collaboration of staff from all sectors of the utility during the WSP process was an asset in resolving any issues with attitude and acceptance. The water provider also saw improvements in attitude among staff members when obtaining support and 'buy-in' from both the bottom and the top (Rand Water, 2007). In Uganda, staff realized quickly that the WSP actually built upon their existing practice, and gave them an opportunity to formalize their procedures. Once this realization took place, staff were more willing to support the WSP (Howard et al, 2005).

Increased Training

In addition to the above institutional outcomes, more formal training can be identified as a need during the WSP process. In Australia, a noted increase in understanding and capacity due to staff involvement in the WSP process led management to implement a formal training program, leading to further improvements in knowledge, increased discipline, and increased ownership among staff for their specific roles (Mullenger et al, 2002). In South Africa, the WSP identified a need for increased training and learning opportunities for internal staff, as well as future employees. To alleviate this problem, the water supplier established professorial chairs at various universities, instituted a skills-building training program, and adopted a two-year graduate training program in which newly qualified graduates are mentored by water provider staff (Rand Water, 2007).

2.3.2 Outcomes: Operational Changes

Operational changes are often the most tangible outcomes of the WSP process. When a risk identified in the WSP process is reduced or eliminated, that outcome is typically accomplished through an operational change. In the six WSP case studies, operational outcomes were observed to fall into two areas: improved system infrastructure and implementation of improved procedures (Figure 5). These operational outcomes usually occur simultaneously or slightly later than the occurrence of institutional outcomes.

Improved System Infrastructure

Development of the WSP itself and WSP-related documents can lead to improved system infrastructure through the use of WSP tools, such as system infrastructure assessments, water quality assessments, and monitoring plans. In the case of Bangladesh, WSPs resulted in direct action by ‘caretakers’ (community water operators) to reduce risks to drinking water, including repairing damaged water source infrastructure, moving sources of contamination, and cleaning the surroundings of the water supplies (Mahmud et al, 2007). The WSP for the Uganda case study called for a system assessment which showed that the sanitary integrity of valve boxes were of concern, as these valves were vulnerable to contamination due to missing inspection covers and the presence of stagnant water in the valve box. As well, many valve boxes also were not designed with a washout facility or an impermeable base. As a result of these findings, the utility placed covers on all valve boxes, checked and fixed any valve packing that leaked, and ensured good external and internal drainage of the valve box. This improvement in system infrastructure was a direct result of the WSP process (Howard et al, 2005).

Implementation of Improved Procedures

Part of the WSP process is the creation of improved procedures for operations and monitoring. WHO’s Water Safety Plan Manual states that “clear management procedures documenting actions to be taken when the system is operating under normal conditions (Standard

Operating Procedures) and when the system is operating in ‘incident situations (corrective actions) are an integral part of the WSP” (Bartram et al, 2009). The Australia case study provides an example of how the Hazard Analysis and Critical Control Points (HACCP) process, a systematic preventive approach to food safety and a precursor to the WSP methodology, aids in identifying areas for development, improvement, and/or change in already-documented operating procedures in a water supplier. The HACCP approach was used by Australia in water safety before the WSP methodology formally existed. Changes to standard operating procedures (SOPs) occurred as a result of the HACCP (WSP-precursor) assessment process, which led to a greater understanding of the implications and potential consequences of actions executed in the field. New SOPs became more effective than previous ones and a sense of ownership among staff developed, ensuring that new procedures were carried out fully. Specifically, the water supplier developed improved procedures for new water mains replacement, as this was identified as a potential risk area and a critical control point in the HACCP (WSP-precursor) plan (Mullenger et al, 2002).

2.3.3 Outcomes: Financial Changes

The WSP process can lead to financial changes for water suppliers, in terms of cost savings, cost recovery, and increased investment (Figure 6). These outcomes generally follow other outcomes, such as the institutional or operational changes discussed above.

Cost savings

WSPs can lead to cost savings for water suppliers, by identifying and implementing more efficient procedures. For example, in Uganda, an analysis was undertaken to estimate what the costs would be to the National Water and Sewerage Corporation of switching to a WSP approach to water quality monitoring compared to the costs of returning to a standard end-product testing approach. The results showed that a 30% reduction in costs of water quality control activities could be achieved, while at the same time maintaining greater assurance of drinking water safety (Howard et al, 2005).

Cost recovery

The operational changes discussed in the previous section often contribute to improvements in service, both in terms of water quality and other factors such as continuity of service, which can lead to increased customer satisfaction (Rizak, et al, 2003). Because consumers are often willing to pay more for better service (Bhandari, 2007; Casey, 2006; Constance, 2004; Whittington, 2002; Whittington et al, 2002), cost recovery may be enhanced through WSPs.

Increased donor support and investment

Because a WSP represents a systematic and holistic assessment of local needs to improve drinking water safety, it can provide a foundation for more efficient and targeted investment in drinking water systems. A WSP shows donor agencies that the water supplier is willing to proactively work with other stakeholders to identify the best ways to improve their water systems. After the initial WSP document was finalized for the WSP pilot project in Jamaica, a representative of the Japanese Bank for International Cooperation, which had been involved in both the WSP and other capital improvement projects, commented that "the WSP demonstrates that the water utility and the government are well prepared to implement and sustain donor-financed improvements" and that "WSPs provide a new stage for funding assistance" (Environmental & Engineering Managers, Ltd, 2007). As WSPs become more widespread, their use as the foundation for identifying funding needs may increase. If cost estimates are added to WSPs, the WSP itself could even serve as a project proposal for capital investment proposals.

2.3.4 Outcomes: Policy Changes

Policy level changes related to WSPs are often the last outcomes to become apparent, only after the other types of changes discussed above have taken place. However, some policy changes can take place more quickly than others. Figure 7 breaks down policy outcomes into three sub-categories: informal knowledge sharing and promotion of WSPs, WSPs as norms of practice, and formal regulatory requirements for WSPs, each of which is discussed below.

Informal knowledge sharing and promotion of WSPs

Initial experiences with WSPs within a country or region can lead to informal knowledge sharing and promotion of WSPs. Others interested in WSPs seek out the early adopters for information about how to get started and pros and cons of the process. This occurred in Uganda, where, once an effective WSP was established for Kampala, other water suppliers became interested in the process and committed to implementing WSPs (Howard et al, 2005).

WSPs as norms of practice

As WSPs become established and the benefits from them become apparent, they may become internalized into norms such as "best practices," which are often integrated into guidance documents that do not carry the mandate of regulations but nonetheless influence how water suppliers and other stakeholders operate. This occurred in the example of Bangladesh, as WSPs became well accepted by Non-Governmental Organizations (NGOs) and other stakeholders as effective guides for consistently ensuring drinking water safety in rural areas. WSP examples and templates, which represented norms or best practices, were developed for different types of rural water supplies in Bangladesh, to facilitate the development of WSPs for these small systems (Mahmud et al, 2007). These norms or best practices are often integrated into written guidance documents, but do not necessarily have to be.

Formal regulatory requirements for WSPs

WSPs may also be incorporated into drinking water regulations, making them mandatory. For example, in Jamaica, after the success of an initial WSP pilot project, the national drinking water regulations were being revised to include a requirement for all water suppliers to undertake WSPs (Environmental & Engineering Managers, Ltd, 2007). Enacting this type of policy change can take considerable time. In Jamaica, the final regulations requiring WSPs will likely not be finalized until 8 to 10 years after the WSP pilot project was initially undertaken in the country.

An evolution within these policy outcomes can take place, as knowledge and promotion of WSPs initially takes place in an informal manner through information sharing and establishment of networks for dissemination of knowledge and lessons learned about WSPs. Later, this type of information about WSPs may become more formalized as norms or best practices in guidance documents. Examples or templates for certain types of WSPs such as small rural systems may also be developed. Finally, WSPs may be incorporated into regulatory requirements at a national or other level, making them a formal mandate for water suppliers. This evolution may pause or stop at any point as well, so that WSPs may never be incorporated into formal regulations in some areas, but remain as best practices. Intermediate steps are also possible; for example, formal regulations encouraging a risk based approach but not explicitly mandating WSPs.

2.4 Impacts

The various outcomes discussed above subsequently lead to impacts, which are the ultimate changes desired as a result of program activities. In this conceptual framework, the initial impact of WSP outcomes (i.e., institutional, operational, financial or policy changes) is improvements in water supply (Figure 3). In the context of a WSP, these improvements are often couched primarily in terms of water quality. However, they may also involve improvements related to other WHO quantitative service factors such as quantity, continuity, coverage, and cost[4] (WHO, 2006).

It should also be noted that not all of the types of outcomes shown in Figure 3 are necessary to lead to impacts. For example, institutional and operational changes may lead to water supply improvements in some cases whereas increased investment may also be necessary in others to achieve this goal. However, any of these changes may lead to improvements in water supplies before policy changes take place.

An example of this initial impact of water supply improvements is provided by the program to develop WSPs for rural communities in Bangladesh mentioned above (Mahamud et al, 2007). Pilot WSP projects undertaken within that program showed improvements in drinking water safety as measured by decreased microbial contamination in the water.

Improvements in water supply will subsequently contribute to improvements in health, although those benefits may not be immediately apparent or easy to measure at an individual project level. In one of the few examples in the published literature where health impacts from a WSP were considered, it appeared that both hospital acquired infections and cases of neonatal

[4] Cost can be important from both an affordability and cost recovery perspective.

sepsis were reduced as a result of a WSP for a German hospital (Dyck et al, 2007). A water system within a hospital is typically a more controlled environment than a community drinking water system, likely making health impacts more apparent and easier to measure, but this result was still only apparent several years after the initiation of the WSP process. Therefore, considerable time may elapse before health impacts become apparent and are measureable.

This conceptual framework for evaluating WSP impacts recognizes that health improvements are influenced by multiple factors, including sanitation, hygiene, food, nutrition and other environmental exposures, and not solely dependent on drinking water safety (Pruss et al, 2002). The framework also recognizes “downstream” effects of improved health. These effects include socioeconomic benefits such as better school attendance (especially for girls), increased time available for economic activities and improved quality of life (Hutton et al, 2004). These features are included to help show the larger context within which efforts to improve drinking water supplies operate, but a detailed discussion of them is not included, as this is not the focus of this paper and they are extensively covered in other material, including the reference cited above.

3.0 Conclusion

Implementing Water Safety Plans can lead to many positive changes, from intermediate outcomes such as increased communication and collaboration among stakeholders to ultimate impacts like improvements in health. It is important to acknowledge all of these changes, and also to recognize that not all of them will occur immediately or simultaneously. Health improvements, in particular, become apparent only after the occurrence of many of the other outcomes discussed in this paper. Despite difficulties in measuring health impacts and the extended time frames for those impacts to become apparent, evidence at the population level makes it clear that efforts to improve drinking water safety will ultimately yield health benefits. In both the U.S. and Japan, widespread implementation of drinking water treatment in the 20th century led to dramatic declines in waterborne diseases such as typhoid fever (Cutler, 2004; Japanese Ministry of Health and Welfare, 50 years’ history of the Ministry of Health and Welfare, 1988, unpublished). More recent examples show the converse: as water treatment was neglected in areas such as the former Soviet Union in the 1990s and more recently in Zimbabwe, there was a resurgence of outbreaks of waterborne diseases such as typhoid and cholera (Mason, 2009; Mermin et al, 1999). Therefore, the link between improvements in water supplies and improvements in health is clear, and the expectation that those improvements in health will occur over time as shown in Figure 3 is reasonable.

Ultimately, however, health and other improvements will only be sustained if water supply improvements are sustained. WSPs are designed to provide iterative opportunities for continuous improvement (WHO, 2009), and so can also help in ensuring sustainability of the drinking water supply improvements resulting from the original implementation of the WSP. Nonetheless, considerable attention must be given to ensuring that drinking water supplies are maintained and supported over the long term in order to ensure sustainability of impacts to both the water supplies themselves and health. For example, if the changes discussed above as outcomes that led to the impacts of improvements in water supply and health are not maintained, then those impacts may not be sustained either.

As this framework demonstrates, the impacts of WSPs must be placed into a larger context beyond simply health. There are various intermediate outcomes (i.e., institutional, operational, financial, and policy changes) resulting from the WSP process that subsequently lead to impacts on water supply and health. Simply focusing on water quality and health improvements in the context of a WSP will overlook these important intermediate outcomes that can provide a better picture of the significance and success of the WSP.

As implementation of WSPs becomes more widespread, more information about the outcomes and impacts from them should become available, leading to broader recognition of the spectrum of positive changes that can result from WSPs. Increased documentation of WSP case studies detailing these results, especially in the peer reviewed literature where broad dissemination is achieved, will also help in this process. This framework can provide a common basis for objectively assessing the outcomes and impacts of WSPs, which will help to establish a strong evidence base for the effectiveness of WSPs. That evidence base will, in turn, help to enable the scaling up of WSPs by providing the information necessary for developing policy environments conducive to widespread WSP implementation.

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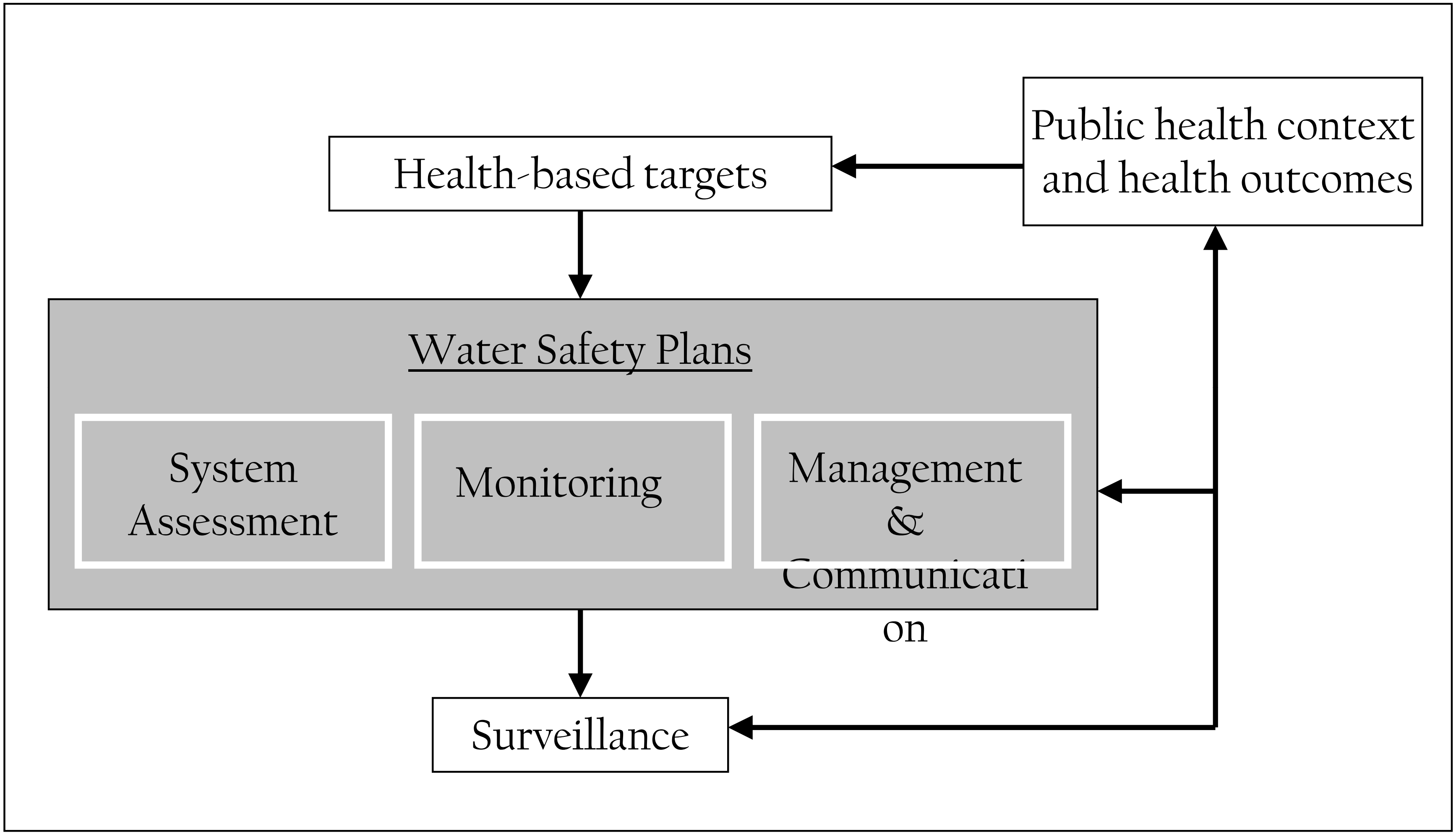
Table 1: Water Safety Plan Case Studies

Country	Description of Water Supply and WSP*
Australia (Mullenger et al, 2002)	This water service provider was one of three retail water authorities operating in Melbourne, Australia, and the first one to obtain HACCP (similar to WSP) accreditation for the supply of drinking water. The HACCP plan (similar to a WSP) was developed and implemented to ensure safe, aesthetically pleasant, and 'up to code' water to its customers.
Bangladesh (Mahmud et al, 2007)	Small rural water system WSPs in 82 communities were developed through consultation with key water sector practitioners in-country. The communities covered were spread across Bangladesh and covered all technologies, except gravity-fed piped water systems. The case study aimed to show that WSPs can be developed and implemented for small community-managed water supplies.
Guyana (Gelting, 2008, unpublished)	This water service provider served a population of roughly 40,000 people in Linden, Guyana. The water service provider operated five water treatment plants and provided household connections for approximately 70% of its residents. The WSP intended to incorporate good watershed management practices aimed at ensuring the integrity of source waters, while optimizing drinking water supply systems.
Jamaica (Environmental & Engineering Managers Ltd., 2008)	This water system in Jamaica was proposed as a pilot project for WSPs in the region. The water service provider served a population of about 140,000 people in Spanishtown, Jamaica, as well as surrounding agricultural areas. The WSP intended to enable the service provider to focus on critical areas for ensuring water of adequate quality. The WSP also aimed to build collaboration between ministries of health, environment, and water sectors, empower water operators to change and improve the water system, and be a model for future WSPs in the region.
South Africa (Rand Water, 2007)	This water service provider was the largest provider in South Africa providing water daily to 12 million customers. It managed two large purification plants, several booster pump stations and an extensive bulk distribution network (including 55 reservoirs). In keeping with modern international standards, the water service provider decided to implement a WSP. The WSP aimed to further improve water quality and safety for its customers.
Uganda (Howard et al, 2005)	This water service provider was responsible for the provision and quality control of domestic piped water in Kampala, Uganada, while the distribution system was managed under contract by a private operator. The system consisted of 871 kilometers of pipline, distributing 94 megaliters of water daily, to approximately 700,000 people. The WSP aimed to provide safe and high quality water to its consumers, as well as demonstrating that WSPs could be successfully implemented in developing countries and offer significant cost savings.

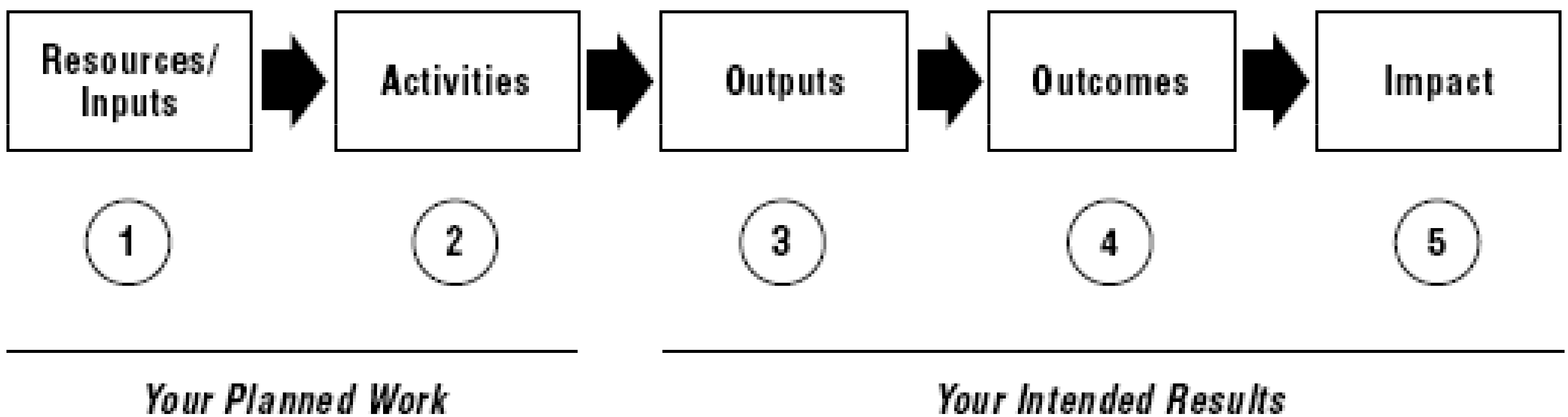
*Description of water supply and WSP as written at the time of the case study

Figure 1. WHO Framework for Safe Drinking Water



Adapted from World Health Organization. Guidelines for Drinking Water Quality, 3rd Edition. Geneva: World Health Organization; 2006.

Figure 2. Logic Model Structure



Adapted from W.K. Kellogg Foundation. W.K. Kellogg Foundation Logical Model Development Guide. Michigan: W.K. Kellogg Foundation; 2004.

Figure 3. WSP Conceptual Framework

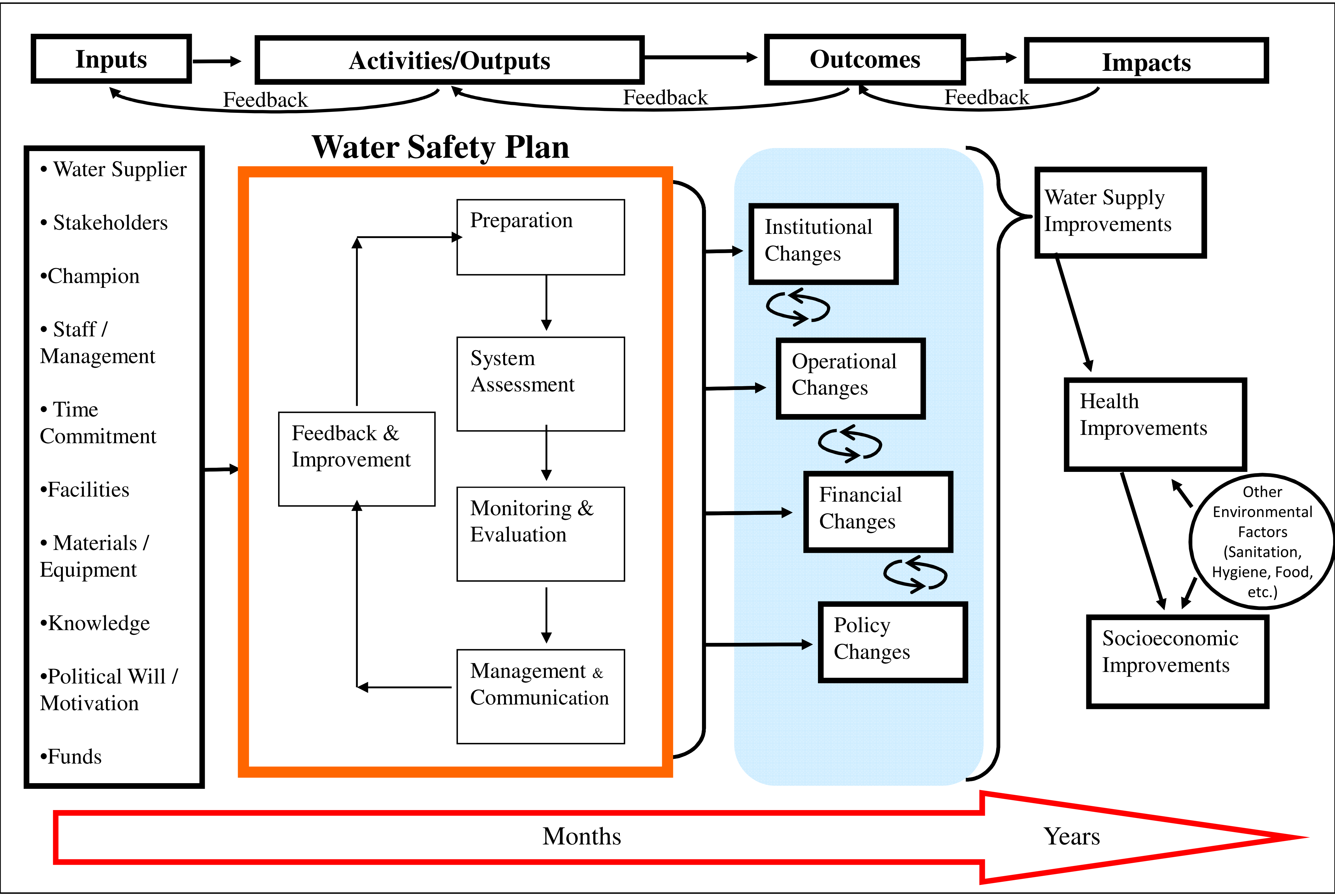


Figure 3: WSP Conceptual Framework

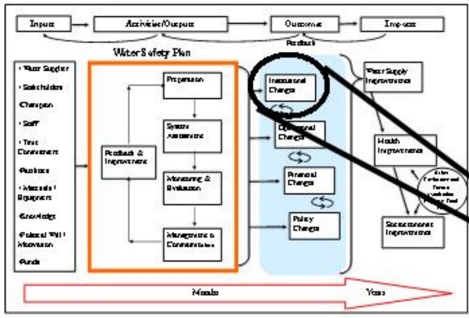


Figure 4. Outcomes: Institutional Changes

Outputs of WSP → **Institutional Change Outcomes**

Case Study Examples of Institutional Change Outcomes

Activities/ Outputs of Water Safety Plan

Increased Communication and Collaboration

-Improved relations between supplier, provider, and regulator, leading to better coordination of efforts to improve drinking water safety *(Guyana)*

Increased Knowledge and Understanding

-Increased knowledge and understanding of water supply system, leading to an improved ability in providing safe drinking water *(Bangladesh, South Africa)*

Improved Perceptions and Attitudes

-Increased acceptance of procedural changes and new terminology *(South Africa, Uganda)*

-Increased ownership by all levels of water supplier when support is obtained from the "bottom" and "top" *(South Africa)*

-Improved ability to formalize existing practices and procedures (*Uganda*)

Increased Training

-Development of training programs within water service provider, leading to improvements in knowledge and discipline *(Australia)*

-Development of skills-building training and graduate training programs *(South Africa)*

Figure 3: WSP Conceptual Framework

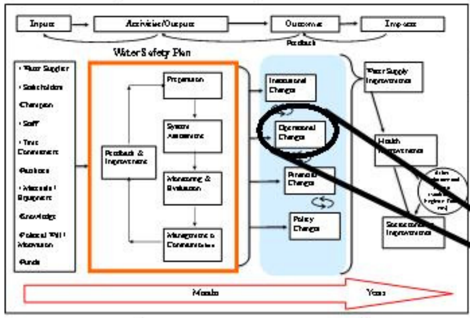


Figure 5. Outcomes: Operational Changes

Outputs of WSP	Operational Change Outcomes	Case Study Examples of Operational Change Outcomes
Activities/ Outputs of Water Safety Plan	**Improved System Infrastructure**	-Direct action by caretakers in rehabilitation/repair to damaged infrastructure *(Bangladesh)* -Direct action by caretakers in removal/repositioning of sources of contamination *(Bangladesh)* -Installation of necessary fixtures, leading to assistance in water quality monitoring *(Uganda)*
	Implementation of Improved Procedures	-Areas for development, improvement, and/or change are identified in already-documented operating procedures, leading to more effective procedures and increased ownership (*Australia*)

Figure 3: WSP Conceptual Framework

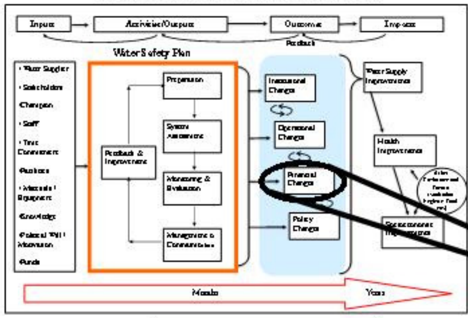


Figure 6. Outcomes: Financial Changes

Outputs of WSP	Financial Change Outcomes	Case Study Examples of Financial Change Outcomes
Activities/ Outputs of Water Safety Plan	Cost Savings	-Reduction in costs of water quality control activities, while maintaining a greater assurance of water quality (*Uganda*)
	Cost Recovery	-Consumers willing to pay more for improved service through WPS, leading to cost recovery
	Increased Donor Support and Investment	-Increase in investment and commitment by donor agencies due to water suppliers being willing to proactively work to improve water systems through WSPs (*Jamaica*)

Figure 3: WSP Conceptual Framework

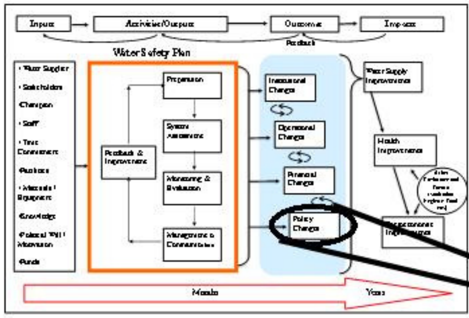


Figure 7. Outcomes: Policy Changes

Outputs of WSP

Policy Change Outcomes

Case Study Examples of Policy Change Outcomes

Activities/ Outputs of Water Safety Plan

Informal WSP Knowledge Sharing and Promotion

-Commitment of other water suppliers to WSP implementation after demonstrated effectiveness by early adopter (*Uganda*)

WSP Model Sharing as Norms of Practice

-Increased recognition and use of WSPs as effective guides for ensuring drinking water safety in rural areas by multiple NGOs (*Bangladesh*)

WSP Formal Regulatory Requirements

-Through incorporation into drinking water regulations, WSPs become a requirement of water suppliers policy (*Jamaica*)