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SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION
**Framework for Drinking-water Safety in Saint Lucia
A Water Safety Plan Approach**

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The Water Safety Plan approach set out in the WHO Guidelines for Drinking-water Quality is based upon scientific consensus, best available evidence and broad expert participation. The approach has been successfully tested in urban areas and building on this knowledge, work is being carried out in rural areas and small islands. This Saint Lucia case-study is part of work conducted in the Caribbean assessing islands for their status in the WHO safe drinking-water framework and how it might lead to improved safety. The Water Safety Plan approach is a holistic analysis assessing all aspects of water safety enabling stakeholders to engage and collaborate with one another potentially resulting in a consensus of opinion based on knowledge and goal-orientated motivation. The time based action plan resulting from the Water Safety Plan approach allows for context specific achievable, incremental and sustainable improvements in drinking-water safety whilst planning for the over-arching goal of a safe drinking-water framework.

Introduction

THE Water Safety Plan (WSP) approach set out in the Guidelines for Drinking-water Quality (WHO, 2004) is based upon scientific consensus, best available evidence and broad expert participation (Bartram *et al.*, 2001). It is a methodology for the management of risks to public health from a water supply and improves awareness of the regulatory and policy framework within which water suppliers must operate (Davison A *et al.*, 2003). Studies and analysis of data from the twentieth century suggest that the traditional approach to verifying microbial safety and microbial standards have little predictive value for public health purposes in certain situations (Bartram J *et al.*, 2003). The identification and enumeration of micro-organisms is slow and therefore not suitable for early warning or control purposes and a holistic approach to quality assurance is needed (Payment P and Robertson W, 2004) that provides a structured system to minimise the chance of failure through oversight or lapse of management which is the Water Safety Plan approach.

Major benefits of developing and implementing a water safety plan include a more in depth understanding of a specific drinking water supply system from source to tap, the systematic assessment and prioritisation of hazards and the monitoring of operational control measures. These control measures can be rolled out in accordance with severity of risk to public health, availability of resources and required planning for implementation which can be used to formulate an action plan to develop a safe drinking-water management structure. This process ensures that safe water is continually supplied and that contingency plans are in place to respond to system failures or unforeseeable hazardous events (Medema G and Smeets P, 2004). WSPs have been implemented with

success in Uganda (Godfrey S *et al.*, 2003) and Australia (Davison A *et al.*, 2003). Similar approaches adopted by Iceland (Gunnarsdottir M, 2005) and New Zealand (Taylor M, 2006) are also proving beneficial to the improvement of drinking-water quality.

In order to verify that the WSP approach can be considered best management practice globally, it is necessary to consider its use in a variety of contexts. To date, WSPs have been evaluated in urban locations and the community water supply setting (Samorka and WHO, 2005). Current work is being carried out in Australia (NHMRC, 2006) and Bangladesh (Alauddin Ahmed *et al.*, 2004) to provide evidence of Water Safety Plan performance in rural communities.

Small islands are particularly vulnerable communities with unique problems. Twelve case-studies in the Caribbean are being carried out to examine the application and sustainability of the WSP approach in the region, of which this study describes one part. The work described here covers the status of the community of Micoud in Saint Lucia in terms of the Water Safety Plan Framework and proposed actions to improve safety.

Saint Lucia is a tropical, volcanic island in the Caribbean Sea which has experienced frequent natural disasters (French A, 2005). It is 616 km² with a population of 148,000 people the majority of whom are indigenous Saint Lucian's (CIA, 2004). A large part of the population is rural working either in tourism or banana cultivation.

In 2002 the Joint Monitoring Program (WHO, 2005) recorded Saint Lucia as having 98% water supply coverage with 75% of the population having a household connection (WHO, 2005). Micoud has a population of approximately 16,000 people and is predominantly a farming community

Table 1. Interviews conducted to identify institutional arrangements of Saint Lucia

Role	Responsibility
Government	
Chief Public Utilities Officer, Ministry of Communications, Works, Transport & Public Utilities	Informal regulation of water supply operations including tariffs and scaling-up.
Director of Water Resources, Ministry of Agriculture, Forestry and Fisheries Member of the Water and Sewerage Commission	Water resources assessment and managing all matters relevant to drinking-water supply. (<i>temporary department</i>).
Chief Environmental Health Officer, Ministry of Health	Public Health and Water Quality Surveillance.
Water Supplier (WASCO)	
Operations Manager	Oversight of operations of water supply operations for Saint Lucia.
Water Services Manager	Oversight of management of water supply on the North side of the island.
Technical Services Manager	Oversee technical operations for the whole island.
Human Resources	Oversight of workforce management and some training.
Water Quality Monitoring (WASCO)	
Water Quality Manager	Monitors water quality.
Other	
Director, Caribbean Environmental Health Institute Member of the Water and Sewerage Commission	Water policy development advice and managing all matters relevant to drinking-water supply in the Caribbean.

of average wealth for the island (Saint Lucia Government Statistics Department, 2006) The average number of people per household is 5, normally residing in two rooms (George A, 2005). The majority of residents have a household connection and there is a public stand-pipe available for others. Some households do not have sanitation facilities (Celestin C, 2005).

Methodology

In order to carry out the study, it was necessary first to conduct an extensive literature review of the WHO policy for drinking-water safety, the challenges of delivering safe drinking-water to communities and existing methods of management in particular those for small islands. The Water Safety Plan framework was applied to collect data about institutional arrangements, catchment, treatment, distribution and domestic systems for each of the case-studies. Key stakeholders were identified for interviews and to gather relevant documents. The Water Safety Plan procedure (Davison A *et al.*, 2003) was followed, *where feasible*, in order to identify the significant hazards in each case-study and a risk assessment carried out. Possible control measures were then established based on literature and interview based evidence of successful hazard prevention for similar problems in other countries or regions.

Interview Development and Data Collecting Tools

Data collecting tools in the form of interviews were devised to establish country characteristics and explore institutional

arrangements. Structured interviews were used to collect information on the catchment, treatment, distribution and domestic systems of the community.

Institutional Framework

The institutional framework interview collected information about the water supply arrangements for the island. This included all government departments with a role in drinking water supply and covered government policy, laws, legislation, regulations and powers of enforcement and an understanding of how the framework had developed. In order to fully understand the strategic framework of an island a senior representative of each government department or organisation was interviewed.

Community Water Supply Interview

This interview was designed to establish the physical characteristics of the water supply and details of consumer usage; how the supply is operated and what resources are available for its operation; water quality monitoring and maintenance. Other sections of this interview considered the drivers for improvement programs of work.

In order to understand the day to day water supply arrangements and issues, those carrying out front line tasks were interviewed. These individuals were selected through preliminary interview with senior management.

Action Plan for Drinking-water Safety

The possible control measures established for hazard pre-

Table 2. Interviews about water supply characteristics for Micoud, including catchment, treatment, distribution and domestic systems

Role	Responsibility
Water Supply (WASCO)	
South-side Manager, WASCO	Oversee WASCO operations for Saint Lucia, south-side.
Ex-south-side Manager, WASCO	Formerly oversaw WASCO operations for the south-side of Saint Lucia.
Engineer, South-side, WASCO	Day to day operations of WASCO community water supplies, Saint Lucia south-side.
WASCO Supervisor, Micoud	Oversees operations and maintenance for WASCO water supply to Micoud.
Water Quality Monitoring (WASCO)	
Sampling Monitor, WASCO	Carries out water quality sampling and testing for all WASCO supplies.

vention will come under the responsibility of a number of drinking-water stakeholders and will be varied in their complexity to implement. Legislation and the identification of appropriate resources for enforcement may take many years of planning and eventual implementation whereas comparatively, the development of simple operating procedures and adherence to them may be established within a smaller timeframe. For these reasons it seemed appropriate to develop a time-based action plan for rolling out control measures based on;

- The severity of risk to public health
- Availability of resources
- Complexity of planning for implementation

Taking into consideration these three factors it was possible to establish the implementation of control measures in the short, medium and long term.

Results

Framework for Drinking-water in Saint Lucia

Primary Legislation

The Water & Sewerage Act (2003) established the Water & Sewerage Commission whose main responsibility is to advise the relevant Ministers about their responsibilities under the Act. The Act splits the responsibility for the provision and protection of water between the Ministry of Agriculture, Forestry and Fisheries (water resources) and the Minister of Communications, Works, Transport and Public Utilities (provision of water and sewerage services).

The management of water resources under the Act includes the protection of water resources, which is split between the Ministry for Health who has the power to take action and the Ministry of Agriculture for the protection of gathering grounds and the provision for the government to acquire gathering grounds; establishment and management of water control areas where water is abstracted for public use; establishment of waste control areas and prevention of the discharge of waste in these areas to protect water resources; provision of water abstraction licenses and permits for water

abstraction and waste disposal in control areas. Supporting legislation for the Water and Sewerage Act (2003) includes provision for catchment protection.

The management of water and sewerage services under the Act include licensing a company to provide water and sewerage services that comply with standards set by the Ministry of Health; reviewing tariffs and tariff schemes; attributing criminal liability for the intentional damage or wrongful connection to water and sewerage service infrastructure and managing the consumer's obligation to pay for services.

Secondary Legislation

The Public Health (Water Quality Control) Regulations (1978) formed under the Public Health Act (1975) come under the jurisdiction of the Ministry of Health and include catchment protection; non impairment of quality of water in gathering grounds, treatment regulations including location of wells, maintenance of chlorination equipment and testing of drinking-water for chlorine residual and distribution regulations incorporating permission for the conveyance of water for domestic use, installation, maintenance and cleanliness of systems and water tanks for conveyance and the powers of the Medical Officer of Health to close a water supply as he sees fit.

The Water and Sewerage Corporation (WASCO), who are the only water utility on the island, licensed by the Water and Sewerage Commission to provide drinking water and, where feasible, work to the cited regulations drawing on Guidelines for Drinking-water Quality (WHO, 1997) for supporting knowledge. The new WHO Guidelines (WHO, 2004) were not widely known by WASCO management.

Hazard Identification and Risk Assessment

Interviews with water supply staff of WASCO (Table 2) identified a wide range of potential hazards to the safety and quality of the Micoud water supply. The water safety plan risk matrix identified the following hazards as the most risk to public health:

Catchment

1. Periods of heavy rainfall causing blockage of intake with silt restricting supply compounded by lack of access to intake for maintenance due to the source being located on private land.
2. Human and animal activity on the catchment posing a risk of faecal contamination of source.
3. Agricultural activity in catchment posing a risk of chemical contamination of source e.g. nitrates, pesticides.
4. Failure of supply for prolonged periods (insufficient stand by or emergency facilities).

Treatment

5. Main microbiological water treatment control measure (Slow Sand Filter) has been abandoned (media removed from filter) because it cannot be maintained (high silt loadings reducing capacity).
6. There are no treatment control measures for dealing with chemical hazards.

Distribution

7. High water loss through leakage.
8. The network is not protected from the risk of ingress of contaminants by backflow.
9. There is little or no control of ingress of microbial contaminants e.g. variable pressure, intermittent supply, repair practices.

Consumer/Buildings

10. Social tendency to avoid using piped water in preference for other sources such as rivers for washing.
11. Cultural belief that water should be free (gift from God).
12. No control/training for plumbers.

Institutional Arrangements

13. Powers of enforcement vested in supplier are not used, mainly due to lack of resources but also encouraged through a lack of clarity over roles and responsibilities and weak management cultures.

Action Plan to improve management structure for Safe Drinking-water in Saint Lucia

The control measures devised appropriate to the hazards identified in Section 3.2 include all aspects of the drinking-water framework in Saint Lucia. Gaps in the current management structure significantly contribute to public health risk and in order to improve drinking-water safety a number of short, medium and long term actions can be formulated resulting from the severity of risk to public health, available resources for improvement and the complexity of planning required for implementation.

Short Term Control Measures**Operator;**

- Catchment: regular clearance of debris at the intake,

abstraction management regime to prevent high turbidity raw water entering the works, monitor and record rainfall.

- Treatment: redirect roof water collection pipe to the beginning of the works, treatment works hygiene, maintenance of chlorinators, fencing off works, plan for power outages, monitor frequency and length of outages, monitor and record drinking-water storage levels and chlorine residual.
- Distribution: leak detection, repair of damaged pipes and biofilm control, maintain cleanliness and integrity of stand-pipes and identify causes of damage.

Meter Reader;

- Install and maintain meters
- Record household water use

South-side Engineer;

- Monthly sanitary survey of the intake and treatment works.

Water Quality Manager;

- Identify and allocate resources for raw and treated water quality monitoring.

Finance Manager;

- Monitoring and communication of costs.

Operations Manager;

- Use of powers in Water & Sewerage Act (2003) to prosecute persons found tampering with or sabotaging water supply infrastructure.
- Consumer communications about possible 'events' and boil water advisories.
- Clarify organisational structure, roles and responsibilities.
- Identify training needs for each role.

Chief Public Utilities Officer, Ministry of Public Utilities;

- Provide support to water supplier implementing short term action plan.

Medium-term Control Measures**South-side Manager;**

- Analysis of drinking-water storage data to develop a proposal for improvements to make supply more reliable.
- Analysis of power supply outages and develop a proposal for a back-up generator.

Finance Manager;

- Analysis of costs and identify procurement policies.

Technical Services Manager;

- Installation of valves at abstraction points to enable some

water management.

- Develop Standard Operating Procedures (SOPs) for operations, maintenance, new installations, leak detection, pipe-laying, pipe maintenance and flushing programs.
- Develop a hygiene code of conduct to be used in conjunction with SOPs.
- Develop and inspection program to ensure that SOPs are being carried out.
- Development of proposal and allocation of resources for meter protection.
- Development of proposal and allocation of resources for back-flow prevention valves for household connections.

Water Quality Manager;

- Monitoring and recording of raw water for microbial indicators and key chemical hazards.
- Report water quality results to operators, managers and public.

Human Resources Manager;

- Identify management training requirements, locate appropriate training facilities and develop a proposal for resources and roll out training program.

Operations Manager;

- Development of proposal for scaling-up of water service infrastructure dependent on analysis data obtained through monitoring.

Project Coordinator of the Water Resources Management Unit, Ministry of Agriculture;

- Monitoring and recording of available water resources.

Chief Public Utilities Officer, Ministry of Public Utilities;

- Development of consumer communication mechanisms to promote payment of tariffs through awareness of cost of supply.
- Gap analysis of institutional framework to support water supplier operations.
- Develop coordination and collaboration mechanisms between all drinking water stakeholders.

Chief Environmental Health Officer, Ministry of Health;

- Development of mechanisms to communicate key water-related public health issues and the benefits to health of using piped supplies.
- Development of hygiene promotion and behaviour change programs.
- Development of program to identify vulnerable groups in the community.

Long-term Control Measures

Long term actions would be informed by data collected by short and medium term actions.

Discussion

Framework for Drinking-water in Saint Lucia

The Water and Sewerage Act (2003) addressed some aspects of the WHO water safety plan framework however, a major problem with the institutional framework was the dissolution of the Water and Sewerage Commission soon after it was established. Licensing of the water supplier is a legal requirement but there is no penalty if licenses are not met so the practice of licensing a sole utility on the island was an academic exercise. There was a realisation that the Commission was not going to work and the World Bank stepped in with reform (Sweeney V, 2005). This has meant that guidelines set out in the Act have become non-viable as there is no agency to enforce them.

The sector is currently being reformed under guidance of the World Bank in order to privatise WASCO. This will be the fourth new Water and Sewerage Act to be adopted in less than twenty-five years however previous reforms have failed and it is not clear that lessons have been learnt. The Director of Water Resources in the Ministry of Agriculture has been working with WASCO to create the new Act, as required by the World Bank and also to address the issue of water resources on Saint Lucia. However, there is no evidence of holistic analysis of drinking-water related issues in Saint Lucia which is vital in order to correctly prioritise measures needed for a safe water supply. For example, a tariff increase in 2000 was 'made arbitrarily without analysis of costs making operations very difficult' (Bushell D, 2005).

Hazard Identification and Risk Assessment

Access to a sufficient quantity of water is well known to be the most important benefit to health and if the intake is regularly blocked then this represents the greatest risk as identified by the Water Safety Plan risk matrix. Quality and continuity in Micoud are intertwined problems. Lack of microbial barriers at the treatment works lead to WASCO stopping abstraction when it rains because of surface run-off increasing turbidity significantly. This problem is somewhat mitigated by drinking-water storage but the tank supplies two communities on alternate days which the operator for Micoud 'finds very challenging' (Martia J, 2005). There is considerable loss of water through leakages and unaccounted for water for WASCO is 45% which has a large impact on the quantity and continuity of supplies in the community. There may also be leaks after the meter as plumbing guidelines have been abandoned. Payment and collection of tariffs is particularly difficult for WASCO as recourse under the current act is disconnection but this is difficult to enforce in the face of extensive leakage. These problems need to be addressed by operational procedures and maintenance work as well as by enabling legislation.

Action Plan for a Framework for Safe Drinking-water in Saint Lucia

The action plan outlined for Saint Lucia was derived using the Water Safety Plan approach and risk matrix which enabled the identification of gaps in the existing framework that contribute to a potential lack of safety in drinking-water and the severity of risk to public health. The action plan has identified improvements that can be made at all levels immediately and in the future. The key stakeholders that may be appropriate to collectively take matters forward are senior water managers and operators (WASCO), the Chief Public Utilities Officer at the Ministry of Communication, Transport, Works and Public Utilities, the Chief Environmental Health Engineer at the Ministry of Health, the Director of Water Resources at the Ministry of Agriculture. Other stakeholders that would also need to be involved are the Department of Planning and the Meteorological Department.

Short-term actions achievable immediately with available resources are mostly the responsibility of the operator. Much of this work is to a certain extent already being carried out but the information needs to be recorded and communicated to facilitate analysis and to enable planning for future improvements.

Medium term actions are potentially achievable in six months to two years. The majority relate to the development of standard operating procedures to guide operators and motivate them through recognition of their role in safeguarding water quality. Analysis of records at this stage would also help to refine the prioritisation of medium term actions. However this would have to be carried out in conjunction with management training to ensure that appropriate solutions to problems are considered. Consumer communication mechanisms are an important part of this stage of the action plan as awareness of the health benefits may significantly contribute to the public support necessary for the associated price policy.

Longer term actions would fall into a planning horizon of 2 to 5 years as these address more permanent remedies to the risks and necessitate engagement of all stakeholders to gain consensus and the political will for changes to the institutional arrangements, securing finance and other approvals for design and construction.

The Water Safety Plan Approach

The Water Safety Plan Approach is a holistic analysis of drinking-water safety that incorporates all aspects of catchment, treatment, distribution, consumer and institutional infrastructure. The methodology requires a team of all stakeholders to come together and share knowledge and understanding of all risks relating to supply, source to tap, and may enable them to have a consensus of opinion about important improvements and how these are prioritised.

The transparency of the Water Safety Plan approach, in that all stakeholders are aware of the problems and potential improvements, empowers individuals to take responsibility for improvements within the scope of their role and to

understand how they contribute to safer drinking-water within the overall drinking-water management structure. The methodology advocates and articulates the development and improvement of drinking-water supplies in incremental stages together with a goal-orientated approach allowing all stakeholders to share responsibility collectively.

Concluding Remarks

Previous improvement strategies in Saint Lucia have not considered all aspects of drinking-water safety and there has been no holistic analysis of hazards to inform risk management strategies. As a consequence improvements have only been a partial success and in many cases did not address the most important risk to public health revealed by this study, namely rainfall impact on quality of raw water making a filtration barrier inoperable. The relationship between quantity and quality and the need to address both together to deliver public health benefits was successfully highlighted by the application of a water safety plan framework.

The Water Safety Plan approach is a holistic analysis assessing all aspects of the drinking-water and may enable associated drinking-water stakeholders to engage and collaborate with one another in order to make improvements, potentially resulting in a consensus of opinion and empowering stakeholders through knowledge and goal-orientated motivation. The time based action plan for safe drinking-water resulting from the Water Safety Plan approach allows for context based achievable and incremental improvements in drinking-water safety whilst planning for the over-arching goal of a safe drinking-water management structure.

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