Introduction

The countries of the Region of the Americas are exposed to a large variety of natural hazards. Earthquakes, hurricanes, volcanic eruptions, landslides, droughts, and floods affect many of the countries of the Region and cause major disasters. The number of deaths, injuries, and persons seriously affected, damage to infrastructure, disruption of public services, and economic losses are on the increase and present a threat to the development of the countries of Latin America and the Caribbean. Table 1.1 lists some major disasters in recent years.

Table 1.1. Selected natural disasters affecting countries of the Region of the Americas and the Caribbean

Year	Event	Name	Area Affected
1987	Earthquake	Napo Province	Ecuador
1989	Hurricane	Hugo	Caribbean
1989	Earthquake	Loma Prieta	California, U.S.A.
1991	Forest Fires		California, U.S.A.
1991	Earthquake	Limón	Costa Rica
1992	Hurricane	Andrew	Florida, U.S.A.
1993	Floods	Mississippi Valley	U.S.A.
1994	Earthquake	Northridge	California, U.S.A.
1995	Hurricane	Luis	Caribbean
1995	Earthquake	Trans-Cucutá	Ecuador
1995	Volcano	Soufrière Hills	Montserrat
1995	Hurricane	Marilyn	Caribbean
1996	Earthquake	Nasca	Peru
1996	Hurricane	Fran	U.S.A.
1997	Earthquake	Cariaco	Venezuela
1998	Earthquake	Aiquile-Totora	Bolivia

If we add to natural hazards the increasing vulnerability caused by human activity, such as industrialization, uncontrolled urbanization, and the deterioration of the environment, we see a dramatic increase in frequency and effects of disasters. Disasters follow a cycle that includes the stage prior to impact, response to the disaster, and reconstruction and rehabilitation activities. The costs of reconstruction consume a major portion of available assets, reduce the resources for new investment, and can delay the development process.

Drinking water and sewerage services are essential in ensuring the health and well-being of populations and as such fulfill an important role in the development process. In emergency or disaster situations these basic services are imperative for the rapid return to normalcy. The impact of a natural disaster can cause contamination of water, breaks in pipelines, damage to structures, water shortages, and collapse of the entire system. Depending on the level of preparedness that the water system authorities have adopted, repair of the system can take days, weeks, and even months.

The best time to act is in the first phase of the disaster cycle, when preventive and mitigation measures can strengthen a system by reducing its vulnerability to hazards.

Drinking water and sewerage supply are the direct responsibility of companies, public or private, that provide the service. A combination of programs are directed at guaranteeing high quality and uninterrupted service to clients. Performance of the systems in emergency situations should be planned in the same way that programs for routine operation and preventive and corrective maintenance are planned. Even during routine operations there are often service interruptions due to equipment failure, breaks in pipelines, and rationing due to low water supply. The risk of damage to water systems in disaster situations dramatically increases with factors such as uncontrolled growth in urban areas, deficiencies in infrastructure, and, above all, the location of system components in areas that are vulnerable to natural hazards.

The forces of nature should not be viewed as uncontrollable, against which no action can be taken. Damage is lessened when measures are taken to strengthen systems and to have response mechanisms in place in the event of an emergency. The implementation of programs that continually update disaster mitigation and emergency response plans guarantee a responsible and effective response to disasters.

Vulnerability analysis, the subject of this document, provides a simple approach for addressing the question: "What is the vulnerability of each component of the system to the impact of hazards existing in an area?" The outcome will assist in defining the necessary mitigation measures and the emergency response procedures should a disaster occur before mitigation measures are carried out, or if the measures do not prevent damage.

Vulnerability analysis is the basis for establishing mitigation and emergency plans for (i) execution of the mitigation measures for different components of the system, (ii) organization and preparation, and (iii) attention to the emergency. It requires a response before, during, and after the disaster and includes a combination of measures with the common objective of reducing the impact on provision of service and enuring that drinking water and basic sanitation services are restored to the affected population in a timely manner.

This book is organized into four chapters. The first explains how an emergency and disaster program is established, and defines the program's content and steps to be taken to develop, execute, and keep the program up to date. The second chapter outlines the principles of vulnerability analysis for drinking water and sewerage systems. It discusses how vulnerability is quantified and how damage probability matrixes are used in the process. The third chapter provides a general description of the major natural hazards and discusses the type of damage they can cause to components of the water system. The fourth chapter presents new approaches to applying vulnerability analysis to different hazards. It provides a detailed description of how to complete the damage probability matrixes.

Three annexes, a short list of definitions, and a bibliography complete this volume.

These guidelines are meant to be consulted by engineers and technical personnel in water service companies to project the performance of drinking water and sewerage systems in case of natural disasters.