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Source Water Protection: A Training Manual for Communities in Nicaragua

A Project of the United States Environmental Protection Agency
and the
United States Agency for International Development

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A Training Manual for Communities in Nicaragua

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Prepared by
Horsley & Witten, Inc.

Table of Contents

List of Figures

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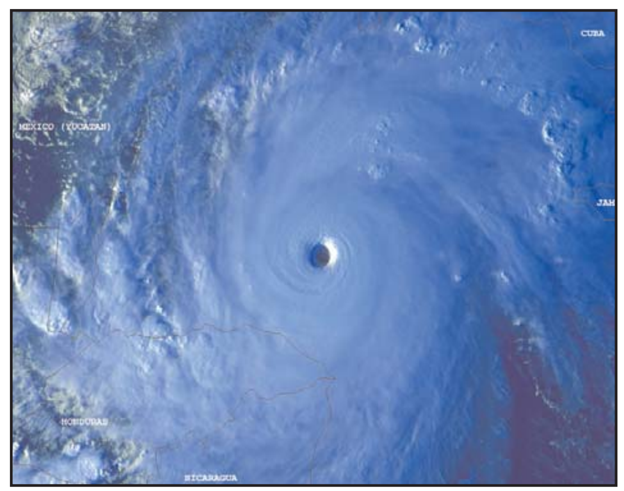
1 Introduction to Source Water Assessment and Protection in Nicaragua

1.1 Background



Satellite image of Hurricane Mitch.
Source: National Oceanic and Atmospheric Administration, 2001

The Nicaragua source water protection technical assistance project, of which this training manual is a part, stems from a Hurricane Mitch relief effort initiated shortly after that disaster struck in 1998. The two agencies primarily responsible for assisting Nicaragua in the development of its source water protection program are the United States Agency for International Development (USAID) and the United States Environmental Protection Agency (EPA). In conjunction with USAID, EPA has been working with three pilot project communities in Nicaragua to introduce some approaches to drinking water management used in the United States. EPA is providing technical assistance to these communities to assist them in adapting and implementing the US approaches to source water assessment and protection and to facilitate work in the communities to aid them in establishing source water protection programs of their own. The project has culminated in the preparation of this source water protection training manual and several training sessions for people involved with water resource protection and management throughout the Hurricane Mitch affected areas of Nicaragua.

The objectives of the workbook are to present useful information to workshop participants on the basic elements of source water protection, facilitate the development of community drinking water protection programs, and enable communities to reduce the impact of future natural disasters on water supplies. The audience for the manual is predominantly community leaders, regional government officials, local and national water utility representatives, engineers, health agencies, educational organizations, consultants, non-governmental organizations, and graduate level university students.

1.2 Introduction

Protection of children's health is a major objective of drinking water protection efforts in Nicaragua.

This training manual is about protecting the quality of drinking water sources in Nicaragua. Clean drinking water is a precious commodity. Both quality and quantity issues routinely present major challenges to communities. One of the difficulties in addressing these issues is the lack of 'source water protection' programs.

Protection of all surface and ground water resources in Nicaragua is an admirable but unrealistic goal. However, focused efforts to protect those surface waters and ground waters that serve as sources of drinking water (generally called 'source water') is not only possible, but vital to the health of every community. Drinking water sources include surface waters, like rivers and streams, and ground water underneath the land surface, accessed through small community wells and larger city wells.

Drinking water sources include rivers and streams.

Clean drinking water is critical to reduce, or even eliminate, the occurrence of many devastating illnesses, especially among children and the elderly. Clean water can also enhance local economies by improving the quality of life, and potentially attracting professionals and businesses to locate in an area, thereby boosting the prosperity of a community. Local communities in Nicaragua can play a pivotal role in protecting public health by protecting drinking water supplies from potential sources of contamination.

What is EPA?

The EPA is an executive level agency under the Office of the President of the United States. The mission of the EPA is "to protect human health and to safeguard the natural environment." Programs within the purview of the EPA include drinking water protection, air quality, hazardous waste cleanup, surface water quality, coastal resource protection, wetlands, human health, environmental management and waste management. The EPA is one of the primary governmental organizations that is responsible for protecting human health and natural ecosystems, and plays a major role in the regulation, protection and improvement of the water resources of the United States. Source: EPA, 2001.

Figure 1.1

What is US AID?

The US AID is a United States governmental agency that provides technical assistance to developing countries "recovering from disaster, trying to escape poverty, and engaging in democratic reforms." The Agency works in six areas: economic growth and agricultural development, population, health and nutrition, environment, democracy and governance, education and training, and humanitarian assistance. It has individual missions in many countries around the world including Nicaragua (Managua). Source: USAID, 2001.

Figure 1.2

1.3 Source Water Protection

Protecting drinking water sources involves several steps, including:

1. Identifying all sources of existing or future water supplies for a community (discussed in Chapter 4).

2. Performing an assessment of those sources by:
   - -Delineating source water protection areas (SWPA's) (discussed in Chapter 4);
   - -Inventorying potential contaminant sources in those areas (discussed in Chapter 4);
   - -Ranking potential contaminant sources (discussed in Chapter 4); and
   - -Increasing public awareness/involvement (discussed in Chapters 5 and 6),

3. Developing a management plan to reduce the potential impacts of contaminants on drinking water sources (discussed in Chapter 5).

In order to achieve comprehensive source water protection, a community must identify, evaluate, and manage its source waters.

These steps comprise a process called 'source water protection.' In order to achieve comprehensive source water protection, a community must identify, evaluate, and manage its source waters. Effective source water protection programs involve collaborative efforts among the people who use and impact the water resource to ensure the safety of that resource. Residents, local officials, water agencies, businesses, and farmers in a community all fall into a group of people known as 'stakeholders.' Stakeholders can represent a variety of social, cultural and economic backgrounds and values, and it is essential that a source water protection program considers and incorporates these differences. While varying points of view may make consensus difficult to reach, best efforts must be made to balance opinion.

Successful source water protection requires extensive stakeholder involvement as a protection program is developed and implemented. With stakeholder involvement, everyone in a community has the opportunity to participate in shaping a drinking water protection program that best fits the needs and resources of the community. A protection program developed by just a small number of individuals with minimal public participation is unlikely to succeed because there is insufficient personal investment in the program by affected individuals and groups in the community. A clear understanding of social, cultural, and economic differences is essential to meeting the goals of overall public participation. The general public would be unlikely to feel committed to the goals of the program. However, with extensive involvement of stakeholders in the planning process, people are far more likely to support implementation of actions to protect the drinking water supply.

Source water protection is best accomplished at the local level of government. Community residents have the largest stake in protecting their own water supply. Community members can work together with local, regional, and national government agencies, taking advantage of existing governmental and non-governmental programs and services to enhance drinking water protection.

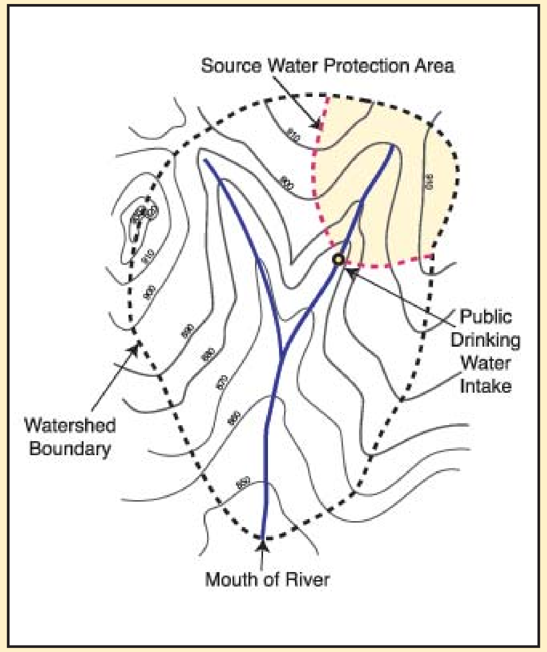
It is important to recognize that community drinking water sources are not governed by community boundaries. Water sources can often be affected by activities and land uses occurring in other cities and towns within the same source water protection area. Therefore, cooperation with and involvement of neighboring communities are critical components of water supply protection. Communities often share a water source such as a river or ground water aquifer, only a portion of which is used as a drinking water supply. It is the portion used for drinking water purposes that must be protected from potential sources of contamination.

Crop cultivation (left) is a potential source of drinking water contamination due to the use of agrochemicals

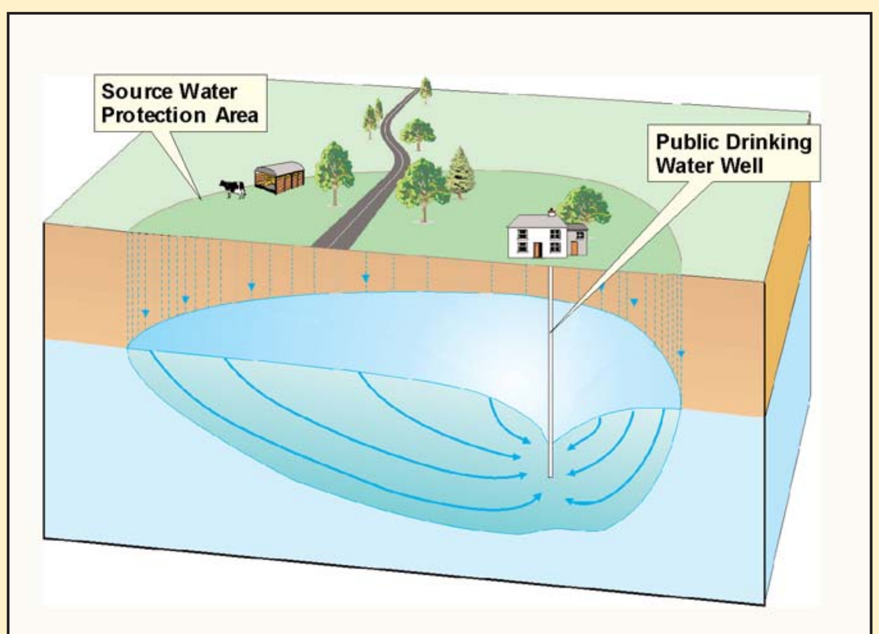
With stakeholder involvement, everyone in a community has the opportunity to participate in shaping a drinking water protection program.

What is a Source Water Protection Area (SWPA)?

A Source Water Protection Area is that land area that does one of two things:



1. contributes overland flow of water to a stream, river, or lake that serves as a drinking water supply, or



2. contributes water that flows to a well that supplies drinking water to a population.

Figure 1.3

1.4 The Training Manual

This training manual provides a step-by-step guide for communities to develop a source water protection program. It supplies information on how a community or group of communities can collaborate to develop and implement a local drinking water protection plan, and how various interest groups in communities can be involved in the process. The manual is designed as an instructional and reference guide for a variety of agencies, organizations and individuals interested in developing and implementing local drinking water assessment and protection programs in Nicaragua. The manual is based, in part, upon experiences gained in the three pilot project communities of Ocotal, Estelí, and Matagalpa. The source water protection experiences in each of these municipalities are described in detail in Chapter 7. Examples from the pilot projects are used throughout the manual to illustrate different approaches that may be useful for community source water protection efforts in Nicaragua.

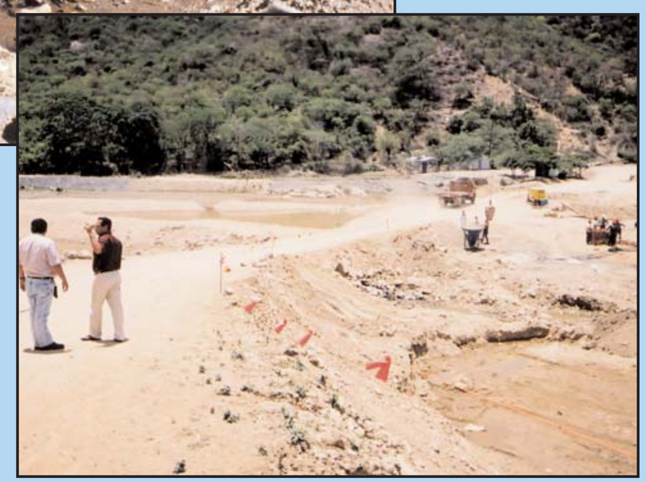
The Impact of Hurricane Mitch

The 1998 hurricane season in the Atlantic Ocean was the deadliest in over 200 years. Hurricane Mitch was the worst of the storms, a Category 5 hurricane with maximum sustained winds over 200 mph. It was responsible for more than 11,000 deaths. Nicaragua was one of the counties hardest hit by Hurricane Mitch. Torrential rains caused widespread flooding and landslides that severely affected the northwestern Pacific coast, the north-central region, and the northeastern Atlantic coast.

This satellite image of Hurricane Mitch shows the immense size of the storm as it hit Central America.
Source: National Oceanic and Atmospheric Administration, 2001.

The aftermath of Hurricane Mitch underscored a tremendous need to develop local programs to manage and protect source waters in Nicaragua. The impact of Hurricane Mitch on Nicaragua's water and sanitation systems was tremendous. The damage and problems continued to multiply days and months after Mitch, due to the deforestation caused by the storm. Severe erosion and mudslides overloaded the already damaged water and sanitation systems. Many communities in Mitch-affected areas were without potable water for extended periods after the storm. The threat of waterborne disease was widespread as a result of contamination of rivers and streams used for drinking water.

Figure 1.4



The heavy rains of Hurricane Mitch caused dramatic erosion in many streambeds (above). This erosion, exacerbated by deforestation of the hillsides contributed to contamination of surface drinking water supplies. The rainfall also washed such huge volumes of sediment into the rivers that sand removal was still ongoing in many areas (right) two years after the storm.

Reconstruction projects have been undertaken to repair and replace the water and sewer systems damaged or destroyed by the hurricane. Emergency health campaigns helped to prevent outbreaks of waterborne diseases following the disaster. But the effects of the hurricane are still visible in Nicaragua and other regions of Central America. Much of the worst devastation following the Hurricane was felt in areas where land uses and water and sanitation services were inadequate prior to the disaster. While it would be impossible to completely control pervasive drinking water contamination during a storm as destructive as Hurricane Mitch, it is possible to reduce the impact of future events, as well as to make dramatic improvements in water quality under normal weather conditions.

This training manual is designed in large part to assist Nicaraguan communities as they develop their source water protection programs. These programs will provide the communities with a greater degree of resiliency in terms of drinking water quality in the event of future natural disasters like Hurricane Mitch.

Figure 1.4 (continued)

2 Water Quality and Community Health

Typical freshwater stream in northern Nicaragua.

2.1 Introduction

Clean drinking water plays a very important role in the health of a community. While most cities in Nicaragua are able to provide treatment for the municipal drinking water supply, the situation is vastly different in rural areas. In rural areas, the number of residents receiving treated water is considerably smaller, and use of untreated drinking water supplies is common. According to the Pan American Health Organization (PAHO), approximately 37 percent of the estimated total Nicaraguan population of 4.46 million people has access to treated drinking water (distributed by piping systems). The urban population is estimated to be 63.7 percent of the total population, or approximately 2.84 million people (PAHO, 1999). Of that urban population, it is estimated that 93 percent has access to drinking water services, while only 12 percent of the rural population has similar access. Forty-two percent of the total population has access to sanitary disposal services (including the use of latrines). Of the urban population, 87 percent benefit from such services, but only 54 percent of the rural population does (PAHO, 1999).

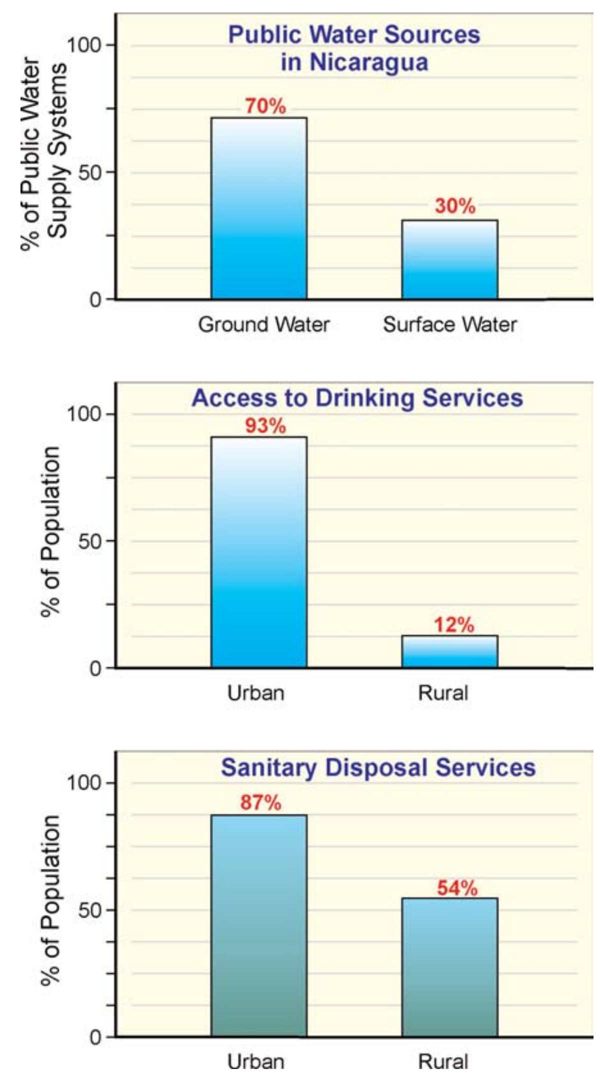


Figure 2.1

Community access to clean drinking water can be improved by protecting drinking water sources and managing them for contaminant reduction and prevention for both present and future uses. In 1990, 70 percent of the public water supply systems in Nicaragua used ground water, while the remaining 30 percent used surface water (PAHO, 1998). While ground water is generally more protected from contamination than surface water, ground water supplies can be extremely difficult to clean up once they become contaminated. They are underground and therefore impossible to see, and water underground moves relatively slowly, meaning that once contamination enters the ground water, it can take many years to show up in drinking water wells. These factors cause ground water remediation to be very difficult, and make protection of these waters from initial contamination extremely important.

Drinking water is aerated during the treatment process to reduce contaminate levels.

The majority of surface drinking water supplies in Nicaragua that receive treatment uses a combination of filtration, settling basins, aeration, chemical additives (to assist in contaminant removal), and chlorination. Chlorine is the most commonly used disinfectant worldwide because it is highly effective against microbes, is widely available, and is inexpensive relative to other treatment options. Water from surface sources must be filtered of sediments and organic matter prior to chlorination. Chlorination of turbid water can be ineffective and chlorine can react with the organic matter to form harmful byproducts such as trihalomethanes, haloacetic acids and chlorite (EPA, 2001a). Further, the amount of chlorine needed to treat all of the harmful bacteria in turbid water can far exceed safe levels for humans.

Treatment plants, such as the one in Matagalpa, also use other chemicals to remove bacteria. For example, aluminum sulfate and calcium oxide are added to the water in specified amounts during the treatment process, based on the quality of the influent water (Proyecto Cuencas Matagalpa, et al., 1999). These chemicals act as coagulants, and promote removal of suspended sediment, thereby enhancing the treatment process.

Settling chambers are used to remove sediment from drinking water.

It is important to note that typical water treatment systems for either surface or ground water supplies do not remove some categories of contaminants, particularly nitrates, organic chemicals, and dissolved metals. For example, a drinking water source contaminated with agricultural chemicals, namely fertilizer and pesticides, or with metals like arsenic or copper from a mining operation, would not be cleansed by treatment processes that remove microbes. Prevention and management of pollutants in a source water area, therefore, play a key role in helping to protect drinking water.

For people who do not receive treated drinking water from a public water supply system, simple filtration methods can be helpful. A sand filter can remove many contaminants from a surface supply of drinking water, including clays and silts, some microorganisms, natural organic matter, iron, and magnesium (EPA, 1999). Sand filters can be used in individual homes or by small groups of several nearby households, as is done in some households in the Dipilto River watershed north of Ocotal. They can also be installed to serve a larger number of people, such as occupants in a hotel or workers at a coffee farm. Selva Negra coffee plantation resort in Matagalpa uses sand filtration to treat water near its source on the mountainside before it is delivered to the hotel and the workers' community.

After water has been filtered, it is possible to disinfect it in the home with chlorine, which can be purchased in liquid form in local stores. It is extremely important that people read, understand, and follow the directions for using this type of disinfectant because chlorine and its byproducts can be toxic to human health if used improperly (Proyecto Cuencas Matagalpa, et al., 1999). While chlorination affects the taste of water, and may be objectionable to some people, the benefits of its use far outweigh the risks of exposure to microbes in drinking water.

Laboratory Capacity-Building Program for Drinking Water Quality in Nicaragua

Water quality testing for drinking water throughout Nicaragua is generally carried out at the centralized MINSA and ENACAL laboratories located in Managua. In some areas, smaller regional laboratories perform basic water quality testing such as bacteriological tests, temperature, pH, and nitrite/nitrate tests. However, the current laboratory system in Nicaragua suffers from inadequate resources for routine testing and monitoring, detailed water quality testing, proper technician training, and modern equipment.

A current project administered by PAHO, part of the United Nations system, is working to build the capacity of the central laboratories of MINSA, ENACAL, and a university laboratory, by providing training and equipment. The laboratory capacity-building portion of this project receiving significant funding from EPA. Eventually this capacity-building program will serve as the foundation for laboratory accreditation in Nicaragua, and capacity building in the regional laboratories.

This work is part of PAHO's Regional Plan of Action to Improve Access to and Quality of Drinking Water in Latin America, which was a product of the 1994 Summit of the Americas. Similar improvements are being implemented concurrently in El Salvador through the same program.

Figure 2.2

2.2 Sources and Health Effects of Common Drinking Water Contaminants

A variety of both natural and man-made contaminants can affect drinking water quality. Typical drinking water contaminants include microbes, nitrates, solvents and petroleum products, pesticides, and metals. The relative occurrence of these categories of contaminants in drinking water in Nicaragua is largely unknown because of limited water quality testing capabilities in the country. However, routine bacterial testing does occur at most if not all of municipal drinking water treatment facilities, and laboratory data generally indicate significant levels of total and fecal coliform bacteria in surface water being used for drinking water supplies. Bacterial data for ground water sources, such as in Estelí, was not available in the regional laboratory analysis data sheet provided by the Nicaraguan Aqueduct and Sewer Company (ENACAL), and may not be collected at many ground water well sites (ENACAL – Estelí, 1999).

Morbidity and mortality data for water borne illnesses is maintained by the Ministry of Health (MINSA), and can provide some insight into the levels of harmful bacterial exposure possible attributable to contaminated drinking water. Such data from exposure to the other types of contaminants (nitrates, solvents, pesticides, and metals) do not generally exist for Nicaragua. However, there is a reasonable likelihood that some or all of these contaminants are present in drinking water, depending on the location of the water supply and land uses in the area. Without water quality data to reveal the levels of these contaminants, it is impossible to speculate how they may be affecting the health of the population. However, general background information of the health effects of exposure to these contaminants is provided in the sections that follow.

The contaminants described in this chapter are likely to affect water quality, to some extent, in every community in Nicaragua. The most pervasive contaminants, based on observation of land use and human activity, are probably microorganisms and nitrates. Depending on the intensity of agricultural and/or industrial activity in a source water area, solvents and petroleum products, pesticides, and metals may or may not pose a significant risk to human health. The degree of risk can be determined largely through the source water assessment process described in Chapter 4.

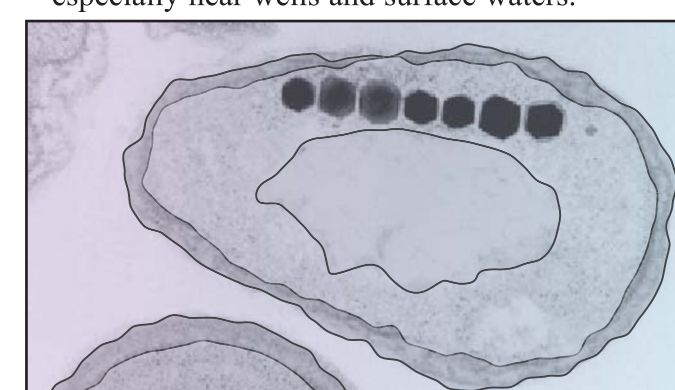
2.2.A Microbial Contaminants

What Are They and What Are the Sources?

Sometimes open defecation takes place in unvegetated areas, where people congregate and wait. Here, coffee pickers wait for a truck to bring their bags of coffee to a drying facility.

Microbes are microscopic life forms. Certain microbes normally inhabit the intestines of humans and animals and aid in digestion. While most microbes are harmless and many even perform beneficial functions, pathogenic microbes can cause illness when ingested with drinking water or food. Harmful microbes include certain bacteria, viruses, and protozoa. These invisible contaminants can get into drinking water in several ways:

- direct urination or defecation by humans and/or animals near or into a stream, river or lake used for drinking water;
- discharge from a sewage treatment plant inside a source water protection area; and
- overflow of waste from poorly constructed or flooded latrines in a source water protection area, especially near wells and surface waters.



This drawing shows a magnified view of a bacterium, invisible to the naked eye.

Testing for Coliform Bacteria

Coliform bacteria are typically found in the digestive tract of warm-blooded animals, but can also be found naturally in the environment. Because they are generally associated with human and animal fecal matter, the presence of coliform bacteria is used as an indicator for other harmful pathogens in drinking water associated with human and animal fecal matter. Human bacterial pathogens include Escherichia coli, Salmonella spp., Shigella spp. and V. cholerae. Two tests are used to identify potential fecal contamination: the total coliform test and the fecal coliform test. The total coliform test is used to determine general levels of bacterial contamination while the fecal coliform test specifically indicates the presence of bacteria originating from fecal matter.

Figure 2.3

What is a Total Coliform Test?

The most common method of testing for total coliforms is the membrane filter method. This is a simple method that can provide results within 24 hours. To perform the total coliform test, 100 ml of water is filtered through a sterile membrane with pore diameter small enough that the bacteria remain on the filter membrane. The membrane is then placed in a dish on a growth medium and incubated in a small specialized oven for 24 hours. After the incubation period, each individual coliform microbe will have grown into a visible colony on the filter membrane, and can be counted. The result of the test is presented as number of bacterial colonies per 100 ml of water. Typically, a drinking water supply is considered clean only when zero colonies per 100 ml of water are present.

(source: Madigan, et al., 2000; Gaudy and Gaudy, 1980)

Figure 2.4

What is a Fecal Coliform Test?

A fecal coliform test indicates only the presence of fecal coliforms, which are a subset of total coliform bacteria. Fecal coliforms grow only in the intestines of humans and animals. The membrane filter method is used for this test as well, but the growth medium and the incubation temperature are different. Bile salts are included in the growth medium so that bacteria that do not grow in human and animal intestines do not grow in the medium, and the incubation temperature is increased slightly. Again, results are measured in colonies per 100 ml of filtered water, and water is only considered clean if the test reveals zero colonies growing on the medium.

(source: Madigan, et al., 2000; Gaudy and Gaudy, 1980)

Figure 2.5

The presence of microbes in a water supply is determined by laboratory tests that culture indicator bacteria on a special growth medium (see text boxes at left). The results of these tests predict the likelihood of the presence of harmful microorganisms in the water.

Children can suffer serious effects, particularly dehydration, from waterborne diseases.

What Are the Human Health Effects?

When certain microbes enter a human body they can cause people to get sick. Different microbes cause different illnesses. The most common illness caused by ingestion of water contaminated with fecal bacteria is dysentery, an infectious disease marked by dangerous hemorrhagic diarrhea. Children can suffer serious dehydration, and in severe cases, may even die. Other common waterborne illnesses associated with microbes in drinking water include cholera, hepatitis A, and typhoid fever (Evans and Brachman, 1991).

Potential Drinking Water Contaminants and Contaminant Sources in the Three Pilot Project Communities

Community	Potential Contaminant	Potential Source
Estelí	Solvents	Machinery, furniture factories, auto repair shops
	Petroleum Products	Gas stations, factories
	Nitrates	Sewage, fertilizer
	Bacteria	Waste and wastewater
Matagalpa	Bacteria	Waste and wastewater
	Natural Organic Material: coffee husks, honey water	Coffee processing
	Pesticides	Coffee farms, agriculture
Ocotal	Bacteria	Waste and wastewater
	Natural Organic Material: coffee husks, honey water	Coffee processing
	Pesticides	Coffee farms, agriculture

Figure 2.6

Water Borne Diseases

Water borne diseases are caused by different types of microbial organisms, including bacteria, protozoa, viruses, and parasitic worms, that can be transmitted in water to humans from other humans and animals. These harmful microbes generally thrive in the gastrointestinal tract of humans or animals and are present in the environment when they are excreted. Once in the environment, these microbes have varying survival times, but can be transmitted via surface runoff, on food, or through direct contact with infected humans and animals (Evans and Brachman, 1991).

Cholera, cryptosporidiosis, typhoid fever and enteric fever caused by *Escherichia coli* are all commonly spread via water when the diseases are present in the human population. A general list of water borne diseases and information on their transmission is provided in the figure below.

Common Waterborne Diseases Transmitted Through Contaminated Drinking Water

Disease	Primary Routes of Transmission
Cholera	Stool to Water
Cryptosporidiosis	Stool to Water
Salmonellosis	Stool to Food
Shigellosis	Stool to Human
Typhoid Fever	Stool to Water
	Urine to Water
	Contaminated Food

Figure 2.7

Microbial contamination of drinking water poses a significant threat to human health in Nicaragua. A cholera epidemic hit Nicaragua and other Latin American countries in the early and mid-1990s. A cholera control campaign in Nicaragua, which involved improved sanitation and public education, brought the number of cholera cases back under control, but only after the control campaign was again challenged by Hurricane Mitch in 1998. In 2000, the number of reported cases of cholera in Nicaragua was down to eleven (PAHO, 2001).

According to MINSA, however, dysentery remains a threatening public health problem in Nicaragua (MINSA, personal communication, November, 2000). In 1990, for example, the number of reported deaths due to diarrhea was 2,166 (PAHO, 1998). The numbers of reported cases of diarrhea in 1993 and 1994 were 255,000 and 264,366, respectively (PAHO, 1999). It can be reasonably assumed that a large proportion of these cases is attributable to ingestion of contaminated drinking water, as opposed to poor hygiene or contaminated food, although the exact proportion is unknown. By 1996, the number of reported deaths due to diarrhea had been reduced to just 82 due to national control efforts (PAHO, 1999), but the number of cases continues to be high.

Intestinal infectious diseases like dysentery and cholera are of additional concern because they are among the leading causes of death of children under one year of age (PAHO, 1998). Of the 2,166 reported deaths from diarrhea in Nicaragua in 1990, 75 percent were children under the age of one (PAHO, 1998).

Source water protection can play an integral role in the prevention of outbreaks of disease, such as dysentery and cholera, caused by microbial contamination of drinking water and food. Cholera and dysentery can be propagated through both inadequate sanitation and contaminated drinking water. Managing land uses, identifying and managing potential contaminant sources, and planning for the future can all contribute to reduced risk to these diseases and can help to limit the magnitude of future disease outbreaks.

2.2.B Nitrates
What Are They and What Are the Sources?

Nitrates are molecules comprised of nitrogen and oxygen in the chemical form NO3. Nitrates are naturally occurring in low levels in the environment as part of the nitrogen cycle. The greatest sources of nitrates are agricultural fertilizers, but human and animal wastes can also contribute nitrates to the environment.

Nitrates can affect both surface and ground water drinking supplies. Treating drinking water contaminated with nitrates is expensive, and can be complicated by the presence of other types of contaminants. While nitrate concentrations can vary over time due to atmospheric sources, agricultural inputs, and weather conditions, it is reasonably safe to assume that nitrates are affecting drinking water quality in Nicaragua, and should be a target of source water management efforts.

Cattle wastes washing into rivers and streams are a significant source of nitrogen and bacterial input to drinking water supplies.

What are the Human Health Effects?

Elevated levels of nitrates in drinking water are of concern because of their potential effect on infants, young children, and pregnant women. Nitrates above 10 mg/l in drinking water can cause blue baby syndrome (methemoglobinemia), an illness characterized by oxygen starvation in the blood, which can lead to mental retardation and, in severe cases, even death. Ingesting nitrates is also associated with elevated cancer risk, especially gastrointestinal cancers.

2.2.C Solvents and Petroleum Products

What Are They and What Are the Sources?

Some businesses and industrial operations use petroleum-based chemicals or man-made organic solvents in the course of performing their work. For example, automotive repair shops often use and dispose of a variety of solvents or petroleum products including motor oil and degreasers. Painting operations use paint thinners, varnishes, oils and stains. Gas stations store and deliver fuel. All of these materials can pollute drinking water if they are not handled, stored, or disposed of safely.

What Are the Human Health Effects?

Solvents can pose significant health risks to people of all ages, especially when ingested routinely over long periods of time, even at seemingly low concentrations. Many organics are associated with an increased risk of cancer in all age groups. They are also linked to liver problems and can impair the normal function of the circulatory and nervous systems. Women may experience reproductive difficulties, and children are at a high risk of developing a spectrum of health problems related to exposure to these chemicals in drinking water (EPA, 2001b, online: www.epa.gov/safewater/mcl.html).

2.2.D Pesticides

What Are They and What Are the Sources?

A pesticide is "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest" (EPA, 2001c). Pesticides include insecticides, which are intended to kill or repel insects; fungicides, which are intended to kill fungi; and herbicides, intended to kill unwanted weeds and plants. In Nicaragua, common pesticides include gramoxone (a herbicide), methamidophos (an insecticide), endosulfan (an insecticide), and metalaxyl (a general use fungicide). When chemicals such as these are used to control weeds and insects in crop production or to control household pests, they can contaminate drinking water supplies either by way of disposal or in runoff. The active ingredients in most pesticides are usually either synthetic organic compounds (such as those listed above), or toxic metals, like copper or arsenic (use of arsenic was more common in the past than it is today). These chemicals are poisonous to humans and can cause short-term effects like headaches, nausea and vomiting, and/or long-term impacts like nervous system damage and cancer.

Ridomil is a trade name for Metalaxyl, a fungicide used on crops in Nicaragua.

What Are the Human Health Effects?

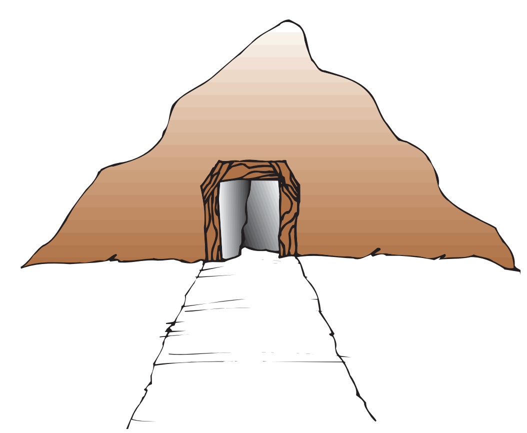
The health effects of exposure to pesticides through ingestion in drinking water are similar to those of solvents. Pesticides are also organic chemicals, and the health effects are often similar. Liver and kidney problems, as well as increased cancer risk, have been connected to pesticide exposure through drinking water (EPA, 2001b).

Children are especially at risk when they routinely ingest significant concentrations of pesticides in drinking water. There are "critical periods" in human development when exposure to a toxin is particularly damaging. For example, pesticides may harm a child by blocking absorption of important food nutrients necessary for normal healthy growth. Also, if a child's excretory system is not fully developed, the body may not fully remove pesticides. (EPA, 2001d)

2.2.E Metals

What Are They and What Are The Sources?

Metals can occur naturally in drinking water sources by leaching from the soil. Metals are also associated with a range of human sources including urban stormwater runoff, industrial or domestic wastewater discharges, oil and gas production, mining, and farming. In acidic soil conditions (low pH), metals that are clinging to sediments from natural or human sources can be released into ground and surface water by leaching from the soils. These metals include naturally occurring trace elements such as lead, mercury, iron, and copper. Concentrations of these metals at greater than trace levels are often associated with industrial or mining agriculture. Metals in drinking water can also originate from organometallic compounds used in organic pesticides (for example, the fungicide copper sulfate) or from wood and leather preservation processes (which often use tin or arsenic) (Manahan, 1994). Lead and other metals can also leach from old water distribution pipes when drinking water is very acidic (low pH).



Mining operations can be a source of metals in drinking water.

What Are The Human Health Effects?

Although at low levels metals are important in the human diet, at high levels they can be dangerous to human health and the environment. Metals can be a serious source of contamination in drinking water. Once metals are dissolved in water, they become available for biological uptake. Metals above standards can be toxic to aquatic life, and can have significant negative human health effects when ingested through drinking water. Some metals can interfere with human and animal nervous system function and others can cause reproductive and developmental problems. For example, inorganic arsenic in drinking water is associated with high incidences of skin cancer and other cancers (WHO, 1993). Copper can have gastrointestinal effects, although the exact levels above which adverse human health effects are seen are not well defined. Lead can accumulate in the human skeleton and can inhibit enzyme development and calcium metabolism in infants and children. Lead is also toxic to the central and peripheral nervous systems (WHO, 1993). While the most common source of lead in drinking water is plumbing and distribution pipes, additional industrial sources are possible and should be managed (WHO, 1993)

Metals Commonly Found in Drinking Water and their Possible Sources in Nicaragua

Metal	Effects of Ingestion in Drinking Water	Sources in Nicaragua
Arsenic	Skin damage, circulation system problems, increased risk of cancer	Erosion of natural deposits, mining byproduct, runoff from glass and electronics production wastes
Cadmium	Kidney Damage	Corrosion of galvanized pipes, erosion of natural deposits, discharge from metal refineries, leachate from disposed batteries and paints
Copper	Short term exposure: gastrointestinal distress; Long term exposure: liver or kidney damage	Corrosion of household plumbing systems, erosion of natural deposits, mining byproducts
Lead	Infants and children: delays in physical or mental development; Adults: kidney problems, high blood pressure	Corrosion of household plumbing systems, erosion of natural deposits

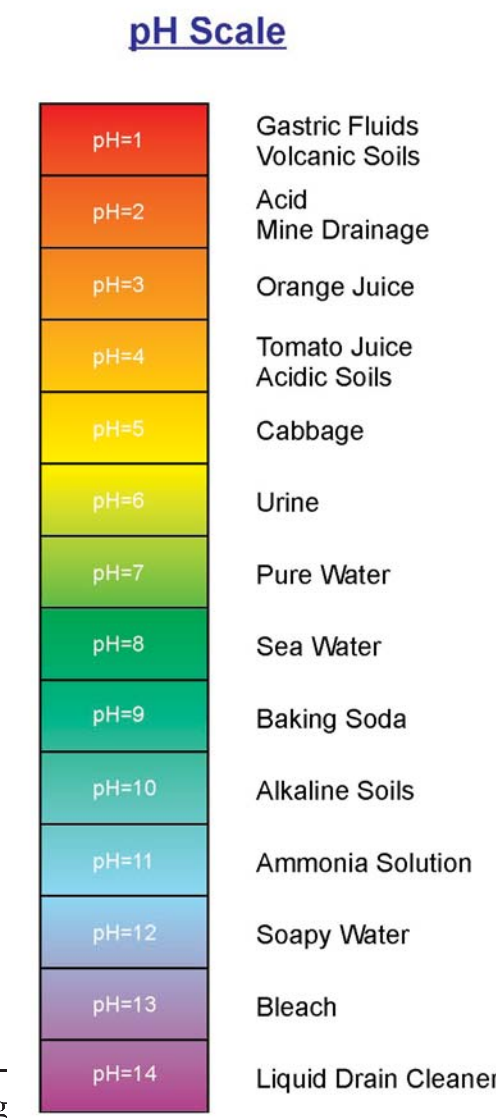
Figure 2.8

Special Risk of Contaminated Drinking Water to Children

Diseases and ailments caused by exposure to various contaminants typically pose a greater risk to children than to adults. Infants and children may be especially sensitive to health risks posed by organic chemicals (solvents, petroleum products, and pesticides) and metals for several reasons:

- their internal organs are still developing and maturing;
- in relation to their body weight, infants and children eat and drink more than adults, potentially increasing their exposure to chemicals in food and water; and
- certain behaviors, such as playing on floors or treated outdoor areas, or putting objects in their mouths, increase children's exposure to chemicals used in homes and neighborhoods.

Figure 2.9



pH is a measurement of the acidity of a substance, based on the concentration of hydrogen ions present. It provides an understanding of the general conditions in the medium being tested, for example, soils, streams and ground water. pH is presented on a log10 scale from 1 to 14, with neutral being pH 7. The pH of natural surface water and ground water vary considerably from one location to another due to the natural conditions of the area, but monitoring of pH changes can provide a good indication of possible contamination of a water source.

Figure 2.10

2.3 Drinking Water Standards

Most countries seek to protect public health by setting legal standards for drinking water quality. In the United States, drinking water suppliers are required to test for an extensive list of pollutants ("priority" pollutants) on a routine basis, and if a violation of a standard is reported, corrective measures must be taken.

Both the EPA National Primary and Secondary Drinking Water Standards under the Safe Drinking Water Act (passed in 1974 and amended in 1986 and 1996; EPA, 2001a online) and the World Health Organization (WHO) Guidelines for Drinking Water Quality (original version published in 1984 and 1985 and revised edition published in 1993 and 1996; WHO, 1996) can be used as references for safe drinking water standards for common contaminants. These standards provide a basis on which governments worldwide can manage, monitor and regulate drinking water quality for the protection of human health. Both documents are available on the internet. The EPA Primary and Secondary Drinking Water Standards can be located on the internet at www.epa.gov/safewater/agua/estandares.html. The World Health Organization Drinking Water Guidelines can be found on the internet in English at www.who.int/water_sanitation_health/GDWQ.

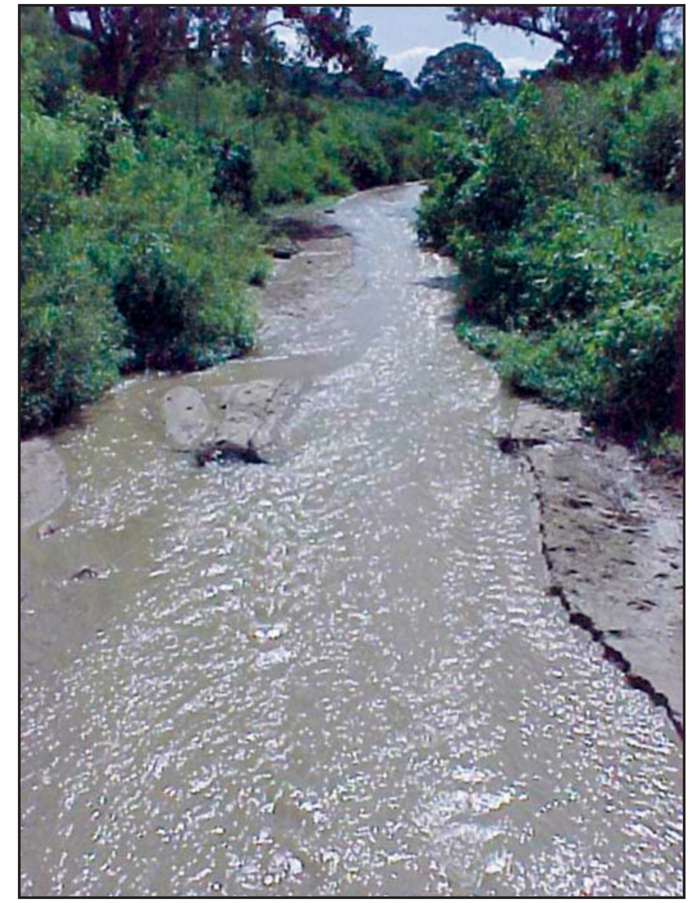
Interpreting EPA Standards and WHO Drinking Water Guidelines

The units of measure applied to both the EPA standards and WHO guidelines are "parts per million" (ppm, also expressed as milligrams per liter or mg/l) and "parts per billion" (ppb, also expressed as micrograms per liter or mg/l). These concentrations are extremely minute. One part per million can be thought of as the equivalent of one minute in two years. One part per billion can be thought of as one second in 32 years. Yet, these minute concentrations are the levels at which impacts to human health have either been documented or extrapolated from research, based on an average person's daily exposure to the contaminants through drinking water (WHO, 1996). It is therefore important to be mindful that even small quantities of certain chemicals entering water can contaminate a large volume of drinking water.

With regard to bacterial contaminants, the drinking water standards are commonly described in number of organisms per 100 milliliters of water (the amount which is commonly filtered for the test). Both the EPA Drinking Water Standards and the WHO Guidelines set the limit of fecal coliforms and other microbes in drinking water at zero (undetectable). While contact with just a single disease organism can cause disease, the higher the concentration of that organism in a volume of drinking or bathing water, the higher the risk of contracting the disease with which that organism is associated. Testing for viruses and protozoa is not common, as the tests are specialized and expensive.

MINSA is responsible for defining the national drinking water quality standards in Nicaragua for all public supplies of water, such as those managed by ENACAL. Water quality testing is carried out at the national water quality laboratory in Managua as well as at several smaller regional laboratories. While improvements to Nicaragua's laboratory capacity are in process (see "Laboratory Capacity-Building Program for Drinking Water Quality in Nicaragua" in this chapter), the quality of all public drinking water in Nicaragua can still not be ensured up to the standards. This is a primary reason in support of a source water protection program in Nicaragua.

Figure 2.11



Data collected by MINSA show that surface water entering the Ocotal treatment plant from the Río Dipilto exhibits bacterial contamination.

Existing Legal Framework for Source Water Protection in Nicaragua

Several national laws in Nicaragua outline the potential significant roles of other agencies in source water protection in Nicaragua. These laws are described in more detail in Chapter 6, but are summarized here:

- The Ley 290, the Ley de Organización, Competencias y Procedimientos del Poder Ejecutivo (1998), outlines the responsibility of all national government agencies.
- Ley 217 , the Ley General del Medio Ambiente y los Recursos Naturales (1996), establishes the responsibility of the Ministry of Environment and Natural Resources (MARENA) for regulating and setting national environmental standards.
- Decree Number 33-95, Disposiciones Para el Control de la Contaminación Provientes de las Descargas de Aguas Residuales Domésticas, Industriales, e Agropecuarias (1995), sets maximum limits on various contaminant concentrations in the discharge of different categories of household, industrial and agricultural wastes into sewer systems and surface waters.

Figure 2.12

3 Benefits from Source Water Protection

Clean water is fundamental to the health of human populations and ecosystems. Beyond the benefit to public health, there are a number of economic, social and environmental advantages stemming from source water protection. However, accounting for all the advantages of source water protection in economic terms is difficult, and the human benefits provided by an unimpaired water supply are rarely explained in the traditional form of economic valuation. Consequently, clarifying the benefits of source water protection is usually done in a qualitative rather than quantitative manner.

3.1 Direct and Indirect Benefits to Human Health

The most obvious benefit of clean drinking water is maintaining public health. Water-related diseases worldwide are estimated to cost at least $125 billion/year in direct medical expenses and lost work time (Gleick, 1998). While improved management of potential contaminant sources will not remove all sources of contamination, it can significantly reduce them. A reduction in contaminants affecting the water resource understandably then translates into a reduction in both direct and indirect costs attributable to drinking water contamination.

Source water protection can benefit coffee workers and others by improving drinking water quality and reducing risks of some illnesses.

3.1.A Family Benefits

The social benefits of source water protection are best expressed in terms of avoided impacts and their associated costs. Generally speaking, an increase in water quality can be expected to result in a decrease in disease, especially in infants, children and the elderly. Costs associated with treating disease, including travel to medical facilities, time away from work, and the cost of medication, can be very burdensome, especially among impoverished or low-income families and individuals. According to PAHO (1998), the average cost per patient to provide health care services and drugs per illness episode was estimated at 30 cordobas for children ages 0-5 years and 65 cordobas for children over 6 years of age. Depending on the illness, the government health center may bear much of the cost, although in some cases the patient's family must bear the bulk of the health services cost.

Whether paid by the government or patients, the costs of water borne diseases in Nicaragua are significant. The average per capita income in 1999 was just less than 4000 cordobas, or approximately US$300 (World Bank, 2001). The annual per capita cost of medical attention resulting from contaminated drinking water could be as much as one to even five percent of the average per capita income, depending on the number of medical visits required in a year (World Bank, 2000).

Many drugs used to target diseases such as tuberculosis, malaria, dengue, and sexually transmitted diseases, as well as drugs to improve the health of mothers and children, should be available free of charge at local health centers (PAHO, 1998). However, the availability of drugs in 1996 averaged only between 60 and 70 percent of the actual need (PAHO, 1998). Clearly, a reduction in illnesses can reduce the strain on an already limited supply of drugs, save significant expenses, and reduce demand on the limited number of trained medical technicians (técnicos) in the country.

Clean water is fundamental to the health of human populations and ecosystems.

Illness has other implications for families as well. It can cause both physical and emotional stress, especially if a family member needs care for an extended time. Care requirements for an ill child or an elder are likely to preclude carrying out of regular household duties or earning daily wages to support a household. Family income can be reduced at the same time that money is needed for medical expenses. School attendance can also go down due to illness or to the need to care for a family member with an illness.

Protecting drinking water sources from contamination could reduce the illness-related costs to families. When the savings to an individual household due to availability of clean water are multiplied across a community or watershed, the total economic value is considerable.

3.1.B Community Economic Benefits

Effective water resource protection at the community level can provide a stimulant to the economy at both local and national levels.

Ecotourism could be advanced in areas with safe drinking water.

For example, dependable potable water and an efficient drinking water delivery system may increase the potential for investment by foreign or domestic companies seeking locations with a solid infrastructure.

Well-protected and well-managed drinking water sources also increase the overall quality of life in a community, and can enhance recreational values in a source water area. Healthy and inviting surface waters (rivers, streams, lakes) provide opportunities for fishing, swimming and bathing. Ecotourism can be advanced as a potentially prosperous business venture if people know there are recreational opportunities and access to a safe source of drinking water in an environmentally attractive area. Property values may also increase over time with improvements in the quality of both surface and ground water resources.

Finally, source water protection reduces the need for water treatment. The cost of maintenance and repairs for a community drinking water treatment plant that is stressed by excessive levels of contaminants can be disproportionately high. Source water protection can help reduce suspended solids in a river (caused by erosion) as well as bacterial loading from livestock and open human defecation. Sediment loads can interfere with the efficiency of a treatment plant, as can sporadic excess loads of bacteria.

Good management of a surface source water protection area can reduce the potential for excessive loads of pollutants to a river. It can also result in more consistent water quality conditions in a surface water source, and thus help ensure efficient and cost-effective operation of the treatment facility.

Source water protection for drinking water wells can also be effective in reducing water treatment needs and associated costs. Chemicals, such as petroleum products or solvents, that may leach into the ground from surface spills, gas stations and other potential sources can eventually reach ground water.

Leaders involved in source water protection efforts may enhance their capacity to accomplish other key tasks in a community.

Ground water contaminated by these chemicals can be very expensive to treat, and in some cases may render a drinking water source unusable. By protecting the area around a drinking water well, the risks of serious contamination and associated treatment costs can be minimized and the source of drinking water can be conserved for long-term use. In areas such as Estelí that depend primarily on ground water pumped through a series of wells located throughout the city, the benefits of source water protection are readily apparent.

3.1.C Capacity Building Benefits

The process of source water assessment and protection can build significant capacity to address other important local issues. Protecting source water is a broad, long-term community undertaking that requires establishment of a comprehensive network of stakeholders. The gains earned from forging ties among stakeholders, including individuals in the community, non-governmental organizations, business associations, schools, and governments, can be significant and enduring. Leaders involved in directing a source water protection program may gain sufficient political standing to accomplish other key tasks within a community. Also, the benefits of successful source water protection in one town can inspire other communities, thereby broadening the impact of one community's success.

3.2 Environmental Benefits

While this manual focuses predominantly on source water protection for the purpose of improving drinking water quality, there are considerable environmental gains to be achieved from safeguarding water resources. A healthy ecosystem able to support the array of flora and fauna native to Nicaragua, generally requires a water source free of significant pollution. When overland flow of water picks up excessive levels of nutrients, chemicals, or harmful microorganisms on its way to join a river or stream, environmental problems can result. Unnatural constituents in water can cause an imbalance in the aquatic environment that may become evident through a change in the animal or plant community, loss of one or more species, and/or an overabundance of one species or group of species, for example an algal bloom.

The Lago Puerto Viejo along the Pan American Highway north of Managua is an example of a surface water ecosystem experiencing an overgrowth of aquatic vegetation. The overgrowth is most likely due to an excessive amount of nutrients (probably phosphorous) in the surface water and/or ground water entering the lake. It can be reasonably assumed that the excess nutrients are coming from fertilizer used on surrounding agricultural land. While water quality tests could help characterize the condition of the aquatic environment, the thick coverage of aquatic vegetation likely indicates the lake is eutrophic, meaning that it suffers from an accelerated growth rate of aquatic plant species. Eutrophication leads to oxygen-starved conditions in a surface water body. It is often true that highly eutrophied lakes such as Lago Puerto Viejo are unable to support normal populations of fish, amphibians and native aquatic plants.

Lago Puerto Viejo

If surface runoff rainwater infiltrating the ground picks up contaminants from a chemical dump or from mine tailings for example, it can carry those materials into the ground water system. When contaminated ground water discharges to a lake, stream, river, or even the ocean, it can damage ecosystems in the receiving waters. In general, ecosystems free of significant contaminant stress are more healthy than contaminated ecosystems, and therefore are better able to provide a normal range of natural benefits.

3.3 Conclusion

Source water protection has significant human health, economic, social and environmental benefits. A community with safe drinking water is a more healthy community, experiencing fewer social costs associated with illness and enjoying more potential for economic well-being. Source water protection efforts can result in immediate benefits, especially if a single problematic contaminant, such as bacteria, is identified and significantly reduced. The greatest advantage of these efforts, however, is the potential for long-term protection of drinking water sources. A comprehensive source water protection program can improve the quality of life for individuals, families, communities, and the nation for generations to come.

4

Source Water Protection Areas

4.1 Introduction

The first step in protecting drinking water is to identify the geographic area(s) that provide drinking water to a river intake or to a well. Such an area is either 1) the watershed area contributing water to that part of a river or stream that is used as a source of drinking water, or 2) a zone of contribution to a well (that is, the land area beneath which water flows to a well that extracts drinking water from the underground aquifer).

After rain water reaches the earth's surface, it generally either seeps into the ground to the underlying aquifer (recharge) or flows overland (runoff) into the nearest downstream surface water body (see Figure 4.1). Protecting source water requires consideration of the entire watershed area, or the zone of contribution through which potential drinking water flows before it is withdrawn from a river or public well.

The simplest way to protect drinking water is to protect and manage the way land is used within the SWPA. The first step in protection is to delineate the source water area and show it on a map. For example, Figures 4.2 and 4.3 show the source water protection area for a surface water source (an intake on a river), and the source water protection area for a ground water source (a well) respectively. These maps provide a candidate SWPA for each drinking water supply.

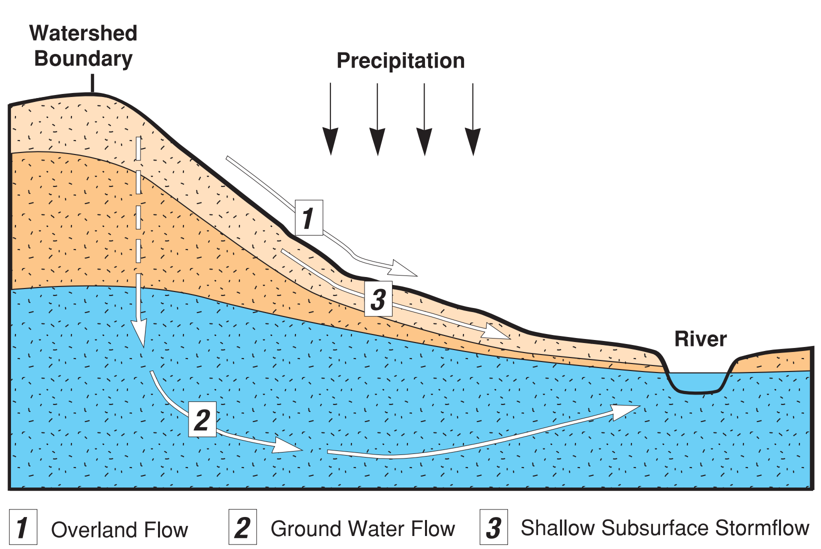


Figure 4.1 Paths of Water Through a Watershed

What is a Source Water Protection Area?

A Source Water Protection Area (SWPA) is defined as the area that supplies water to a public water supply, ground water well, or surface water intake. It is this area through which contaminants are likely to pass and eventually reach the ground water well or surface water intake. The SWPA can be delineated using one of several methods, which are described in Sections 4.2 and 4.3.

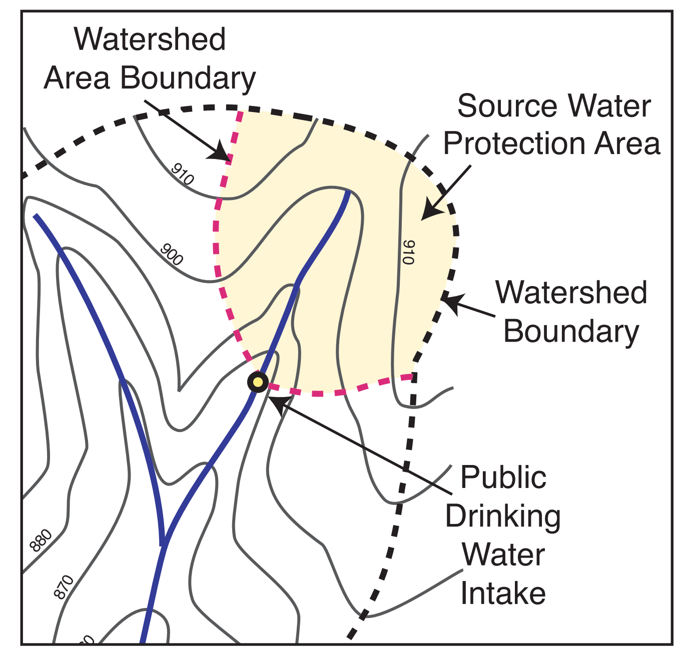


Figure 4.2

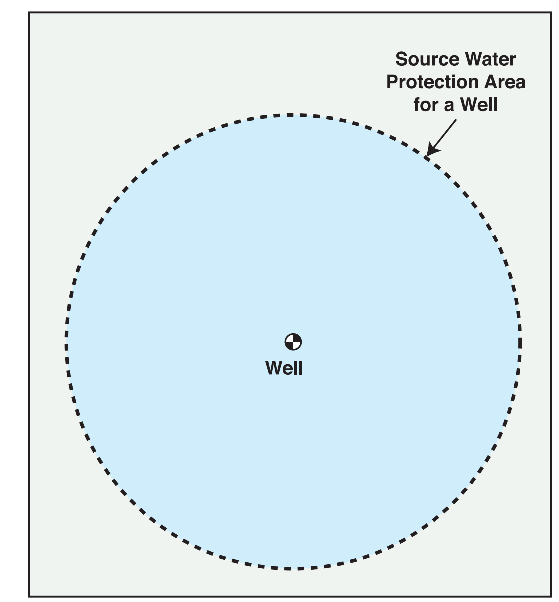


Figure 4.3

What are Watersheds and Watershed Areas?

Watershed: The land area (sometimes referred to a drainage basin) from which water drains into a receiving body of water (including lakes, ponds, wetlands, embayments, estuaries, and oceans) or to the terminus of a river, stream, or tributary (Figure 4.4).

Watershed Area: The land area from which water drains to a point on a receiving body of water (Figure 4.2).

4.2 Delineating and Mapping Source Water Protection Areas for Surface Water Sources

Source water protection areas for surface water and ground water sources are delineated using different methods.

The boundaries of a surface watershed are sometimes obvious. Often, the hills or mountains surrounding the drainage basin form clear boundaries and the shape of the watershed can be easily visualized. Where the watershed boundary is less easily visualized, a topographic map is used. The boundary of a watershed can be defined by asking for any point X on the map: "If a drop of water falls here, will it eventually flow to the mouth of the river or stream of concern?" The answer can be determined by tracing the flow path of the drop from higher elevations to lower elevations, its direction always staying perpendicular to topographic contour lines. If the answer is yes, then that point is within the watershed. If the answer is no, then that point falls outside. However, it is important to note that every point falls within some watershed, even if it is not the current watershed of concern. Figure 4.4 illustrates this point.

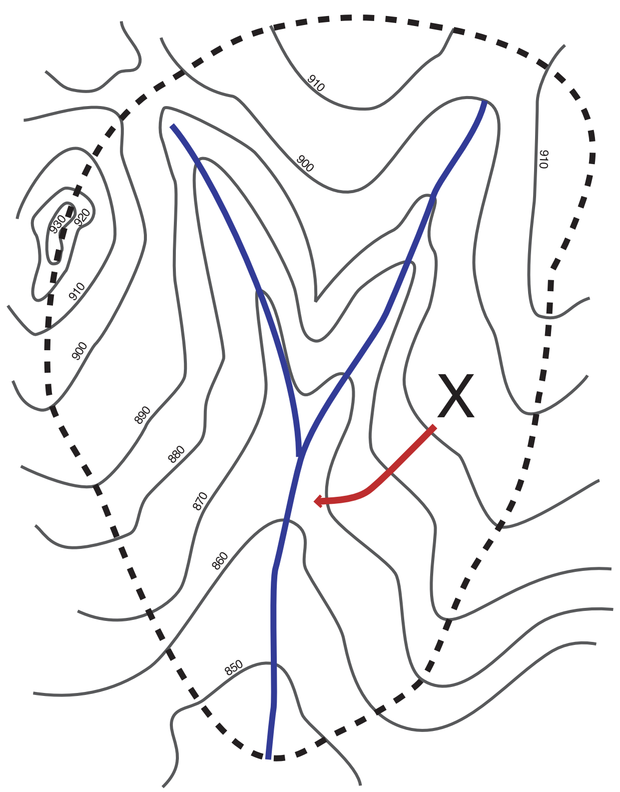


Figure 4.4 The boundary of a watershed can be defined by asking, "If a drop of water falls to the ground at point X, will it eventually flow into the river or stream of concern?"

How are watershed area limits drawn for surface water sources? First, the point along the surface water body that marks the drinking water intake is located on the topographic map. All of the land uphill from this point, and from which water drains, is the watershed area. This is commonly a subset, or sub-watershed, of a larger watershed associated with an entire river. The upper boundary of the watershed area coincides with the boundary of the watershed (Figure 4.5). The boundary along the down gradient edge of the SWPA will be estimated using a topographic map as a reference. All the water in the watershed area will flow down gradient through this single point. Starting at the intake location, a line is drawn along the land surface that is directly perpendicular to every contour line on the topographic map. The upper boundary of the watershed area will likely be easily defined based on topography. The down gradient boundary will likely have to be estimated since this boundary does not usually coincide with the natural watershed boundary. Figure 4.5 illustrates this point.

In some cases, the available topographic maps may not present enough detail or may not be at a scale useful to delineate the watershed area. In these cases, individuals will need to visit the stream and tour the watershed in order to estimate the boundaries of the watershed area based on observation.

Watershed areas can be subdivided to facilitate different levels of protection. In general, those portions ('sub areas') closest to the drinking water intake will have the shortest travel time and the shortest distance over which particulates may be naturally removed, and therefore might be placed under a higher level of protection or management. Definition of sub-areas allows communities to prioritize protection and management activities within the watershed area. Other criteria that can be used to subdivide protection areas include soil type, vegetation and slope of the ground within the SWPA.

4.3 Delineating and Mapping Source Water Protection Areas for Wells

Many public water supplies are wells that pump water from a ground water aquifer. For example, the community of Estelí pumps its drinking water from a series of 16 wells that are located in and around the city. As in most urban centers, these wells are susceptible to contaminants from surface activities and land uses, such as oil from cars and buses, pesticides and fertilizers from local agricultural fields, or release of industrial chemicals. Discharges of pollutants from land uses at the surface can mingle with rainwater as it infiltrates downward and reaches the aquifer, possibly having a negative effect on the quality of drinking water pumped by the wells.

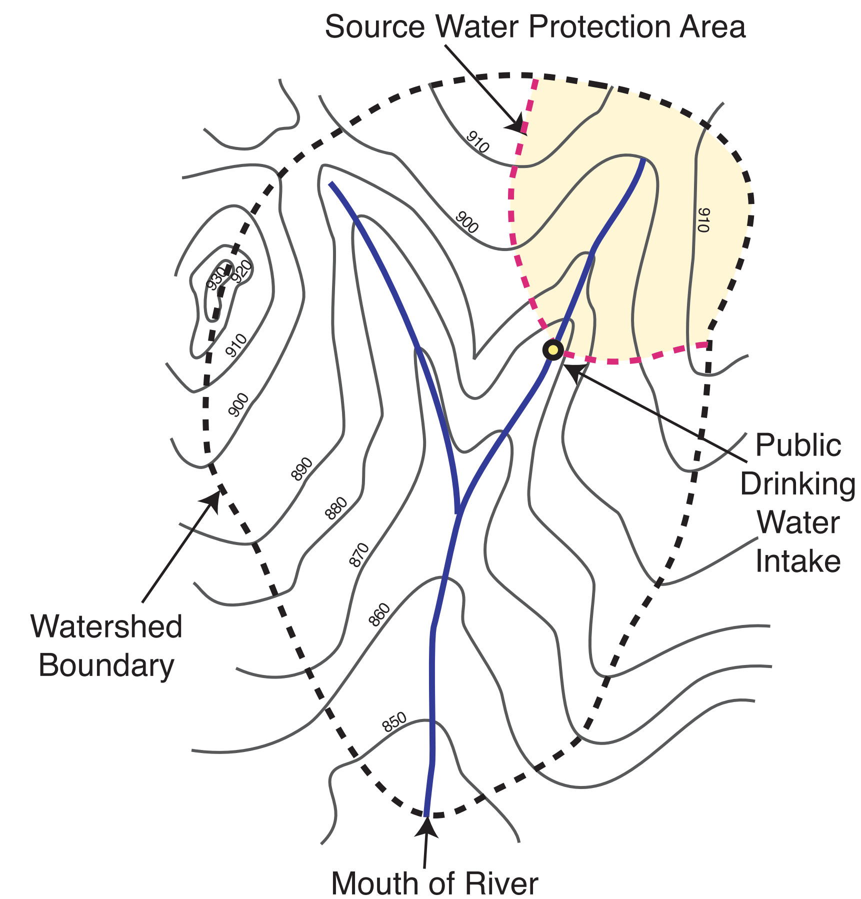


Figure 4.5 Delineating a watershed for a surface drinking water source. The area contributing to a surface water intake is commonly a subset of a larger watershed.

When a well is pumped, it pulls water from the underground aquifer, causing water surrounding the well to move towards the well. Water that falls on the land surface and recharges the aquifer may eventually get pumped back out of the ground through a well.

The land area that contributes water to the well is the zone of contribution for the well. Figure 4.6 is a very simplified cross sectional diagram showing how water flows through a zone of contribution to a well. Using information about the physical characteristics of the aquifer, the rainfall and recharge rate (how fast the water seeps into the soil and reaches the aquifer below) in the local region, and the rate of pumping of the well, we can estimate the boundary of the well's zone of contribution, which may serve as the source water protection area (SWPA).

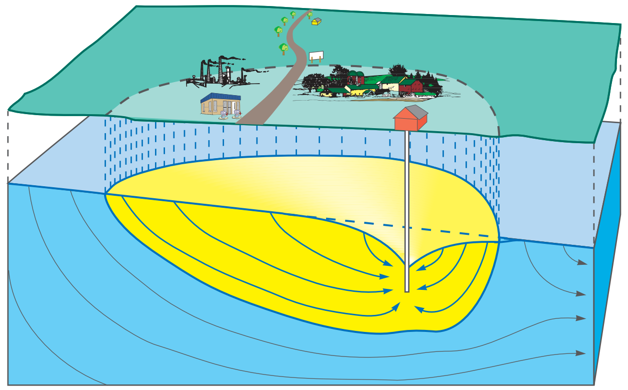


Figure 4.6 Paths of Water Through a Zone of Contribution to a Well

The following methods are applicable to places like Estelí where there are sand or sand and gravel aquifers. In other places where the aquifers are fractured rock, mapping source water protection areas for wells is more difficult. Extensive drilling and geophysical investigation are required to accurately understand the subsurface network of rock fractures that may hydraulically connect to a given drinking water well. However, this manual does not go into detail on methods to accurately delineate source water protection areas for wells in these circumstances. The amount of investigation and analysis required is beyond the scope of this training. In the United States, some states have faced this problem. In general, the United States program recommends using a 1/4 mile (approximately 400 meters) radius until more site-specific information can be gathered.

(Further information may be found at the EPA website (www.epa.gov)).

A number of different methods may be used to delineate source water protection areas for wells (that is, the zone of contribution of ground water to a well). Usually, the method that is used will depend on the amount and types of data that can be obtained, as well as the availability of a technical staff. Delineation methods include:

- Calculated Fixed Radius
- Analytical Methods
- Numerical Methods
- Hydrogeologic Mapping

All of these methods are described briefly here, but we will only provide detailed examples of the first two methods. These first two methods are commonly used and provide a very useful starting point for community-based source water protection. The remaining two methods require a great amount of data, technical skill, and computer modeling, and are therefore less easily implemented.

Source Water Protection Area for a Well Based on the Hydrologic Balance Equation in the Calculated Fixed Radius Method

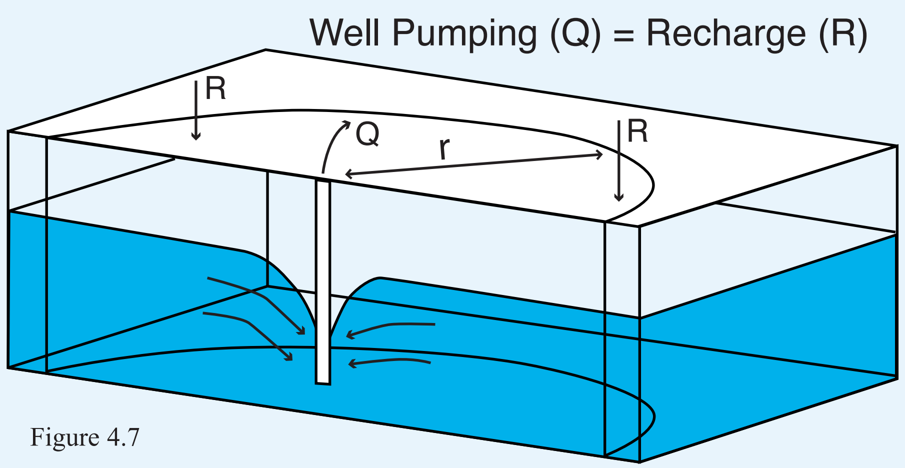


Figure 4.7

1. Calculated Fixed Radius. In these methods of delineating source water protection areas for a well, a circle is drawn around the well based upon hydrologic data, such as recharge rate or time of travel of ground water.

One calculated fixed radius method is based upon a hydrologic balance between the pumping rate and the recharge rate. This method uses a simple equation based on the volume of water drawn to the well during a specified time period, and requires knowledge of the pumping rate of the well and the recharge rate for the aquifer. The recharge rate can often be estimated by determining the annual rainfall and subtracting estimates of evapotranspiration (evaporation plus the transpiration from plants) and surface runoff over the course of a year.

The radius of the circle that defines the protection area is determined by the following equation:

$$r = \sqrt{Q/R\pi}$$

Where r = radius of the protection area (feet)
Q = well pumping rate (cubic feet/year)
R = recharge rate (feet/year)

Another type of calculated fixed radius method uses the volumetric flow equation. This equation allows the volume of the aquifer from which water flows to a pumping well, over a specified amount of time, to be calculated. Based on that volume, the corresponding radius of the protection area on the ground surface can be determined. If the goal is to protect the wellhead from specific known contaminants, the travel time can be specified to correspond with the probable decay rate or sorption rate of a contaminant of concern so that the amount of contaminant that reaches the well is minimal or zero. However, little is known about these rates in ground water. Therefore, communities often base protection radii on management priorities. In the U.S., a community can use radii that coincide with a estimated travel times of the ground water that are considered to be reasonably protective. These travel times are 2 years (especially when the concern is coliform bacteria) or 5 or 10 years when other contaminants are the primary concern.

Use of the volumetric flow equation requires knowledge of the pumping rate of the well, the travel time for water to reach the well, the porosity of the aquifer (determined by type of material in the aquifer), and the length of the well screen (from well construction records). The volumetric flow equation can be used in the following form to determine the radius of the protection area:

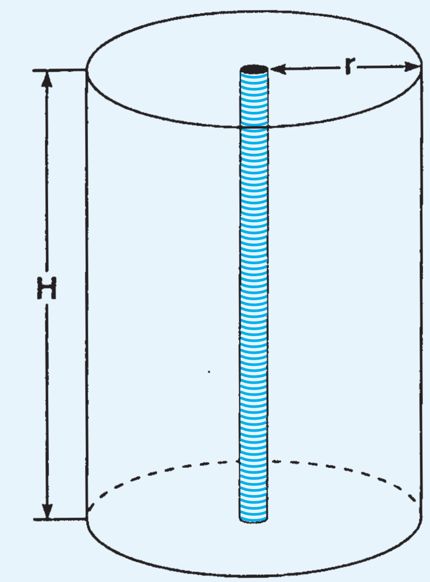


Figure 4.8 Volume of Aquifer Needed to Supply the Well, Using the Volumetric Flow Equation in the Calculated Fixed Radius Method

$$r = \sqrt{\frac{Qt}{nH}}$$

Where r = radius of the protection area
Q = well pumping rate (feet)
t = travel time to well (years) (based on community's management priorities)
n = porosity of the aquifer
H = length of the well screen (feet)

Candidate Source Water Protection Areas for Drinking Water Wells in Estelí

University students in Estelí have delineated candidate SWPAs for all 16 drinking water wells in the city. They worked with representatives from ENACAL to gather data on locations of the wells and pumping rates, and estimated the rate of recharge of precipitation to be about 50 percent of the total rainfall in the region. These SWPAs are only suggestions and have not been adopted as legally recognized protection areas.

Figure 4.9

2. Analytical Methods. A number of analytical methods have been developed to predict the ground water flow patterns surrounding a pumping well. Analytical methods often require the input of hydrogeologic parameters, for example, transmissivity, porosity, hydraulic gradient, hydraulic conductivity, and saturated thickness of the aquifer. Analytical methods generally involve computer modeling.

These methods simulate the movement of ground water as a function of pumping rates, aquifer characteristics and water table conditions. One type of analytical method that utilizes the uniform flow equation has been commonly used. This equation, like other analytical methods, requires more detailed hydrogeologic data than the previous method. Specifically, the pumping rate of the well, the hydraulic conductivity of the aquifer, the saturated thickness of the aquifer, and the hydraulic gradient of the aquifer are required data. This equation provides the down-gradient (XL) and lateral limits (YL) of the protection area around the well.

The uniform flow equation can be solved for the down-gradient and lateral limits of the protection area, as shown below:

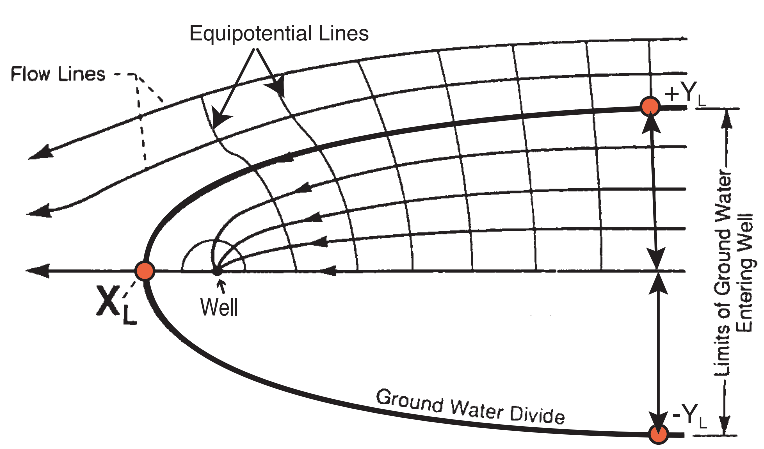


Figure 4.10 Source water protection area for a well using the uniform flow equation

$$X_L = -\frac{Q}{2\pi K b i}$$

$$Y_L = \pm\frac{Q}{2 K b i}$$

Where:
Q = Pumping rate of well (cubic feet/day)
K = Hydraulic conductivity (feet/day)
b= Saturated thickness (feet)
i = hydraulic gradient (rise/distance)

The uniform flow lines (Figure 4.10) indicate the direction of flow of the ground water. The equipotential lines indicate lines of equal water table elevation within the ground water aquifer. The line intersecting the equipotential lines at right angles and passing through the three points designated on Figure 4.10 (XL, –YL, and +YL) forms a parabola that delineates the down-gradient and lateral limits (that is, the ground water divide) of the protection area. The method does not indicate where the up-gradient limit is located. One way to estimate the up-gradient limit is to combine this method with the calculated fixed radius approach. The up-gradient boundary of the protection area calculated by the uniform flow equation would then be located where the area of the entire protection area is equal to the area calculated using the calculated fixed radius method.

3. Numerical Methods. Numerical methods generally require a computer program and more extensive field data. These methods allow for two- and three-dimensional modeling of aquifers. The study area is divided into a computer-generated grid to which values of water table elevation, hydraulic conductivity, and aquifer thickness are assigned. The model then simulates changes in the water table elevation in each grid in response to pumping of the well. The resulting depression in the water table is then used to delineate the protection area. An example of a computer model that uses numerical methods is MODFLOW, a frequently used program developed by the United States Geological Survey (USGS) to simulate ground water flow. This method requires specialized expertise in hydrogeologic and computer modeling, and may, therefore, be impractical for most communities.

4. Hydrogeologic Mapping. Hydrogeologic mapping can be used to map flow boundaries based on geologic, geomorphic, geophysical and dye-tracing information. Because of these requirements, it is best suited to smaller aquifers with near-surface flow boundaries. This method requires specialized expertise in geological and physical mapping, dye tracing methods, and flow boundary analysis and may therefore be impractical for most communities.

Source water protection areas for wells can also be delineated using a combination of the methods presented above. This approach may be helpful in designating different levels of protection within the overall protection area. For example, Figure 4.11 shows a three-tiered source water protection area for a well. Zone I represents an arbitrary fixed radius at 100 meters. Zone II is based on an analytical flow model, and Zone III is based on hydrogeologic mapping.

It is important to note that the candidate SWPAs for wells can overlap with one another or can be too large for a community to effectively manage. For example, in the case of the candidate SWPAs delineated by the university students in Estelí, the SWPAs overlap such that almost the entire land area of the town would fall within a protection area (see Figure 4.9). As a result, management of these SWPAs may prove very difficult. In order to balance the size of a SWPA with the effective manageability of the SWPA, it may be necessary to alter the delineation method or assumptions in order to decrease the area of the candidate SWPA(s) by reducing them before they are finalized.

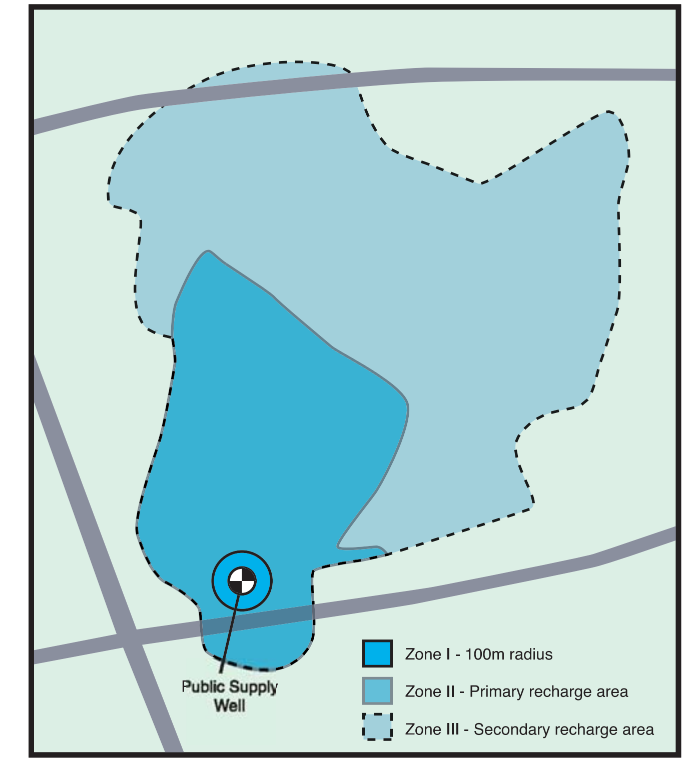


Figure 4.11 Three-tiered source water protection area for a well.

4.4 Identifying Potential Sources of Pollution

Once the protection area around a community drinking water source has been delineated, the next step is to identify and map the potential contamination within the protection area. Common potential sources of contaminants in the pilot project communities, and probably in many communities in Nicaragua, are manure from livestock (especially cattle), pesticides and fertilizers from agricultural fields, solvents and petroleum products from automotive repair shops or garages, and discharge water and coffee husks from coffee processing facilities.

Potential sources of contaminants can be identified by researching and observing the activities that occur within a mapped source water protection area

List of Potential Contaminants and Contaminant Sources for Wells in Estelí	
Potential Sources (Commercial and/or Industrial)	**Type of Contaminant**
Automotive Factories	Acids, Antifreeze, Metals, Petroleum Residue, and Solvents
Cement Factories	Acids, Metals, and Solvents
Chemical Processes of Hydrocarbons	Acids, Metals, Petroleum Residue, and Solvents
Construction/Demolition	Acids, Dusts, Metals, Sediments, and Solvents
Laundromat	Solvents
Dry goods Factory	Acids, Metals, Solvents, and PCBs
Repair and Manufacture of Electrical Products and Electronics	Acids, Metals, Solvents, PCBs, and Dusts
Bus and Taxi Terminal	Acids, Antifreeze, Metals, Petroleum Residue, and Solvents
Processing of Foods	Acids, Metals, and Solvents
Funeral Services and Cemeteries	Nutrients, Pesticides, and Solvents
Repair and Manufacture of Furniture	Metals and Solvents
Gas Station	Antifreeze, Metals, Petroleum Residue, and Solvents
Hardware Store and Lumber yard	Acids, Metals, and Solvents
Deposits of Trash	Metals, Pesticides, and Solvents
Manufacture of house products	Acids, Metals, Sediments, and Solvents
Deposits of scrap iron	Acids, Metals, and Solvents
Laboratories	Acids, Metals, Petroleum Residue, and Solvents
Centers of repair of machines	Acids, Antifreeze, Metals, Petroleum Residue, and Solvents
Centers Doctors and veterinarians	Acids, Antifreeze, Metals, Petroleum Residue, and Solvents
Metallurgical factories	Acids, Antifreeze, Metals, PCBs, and Solvents
Military Bases	Metals, Pesticides, Petroleum Residue, Radioactive Remainders, and Solvents
Mining/extraction of sand and gravel	Metals, Sediments, and Solvents
Office buildings	Acids, Antifreeze, Metals, Petroleum Residue, and Solvents
Photograph development	Acids, Antifreeze, Dusts, Metals,
Petroleum Residue	Wastes, and Solvents
Manufacture of plastic and synthetic products	Acids, Antifreeze, Smoke, Metals, Petroleum Residue, and Solvents
Centers of sale	Acids, Metals, and Solvents
Tanks of underground storage	Metals, Petroleum Residue, and Solvents
Treatment of wood	Creosote, Metals, and Solvents
Processing of wood	Acids, Antifreeze, Metals, Petroleum Residue, and Solvents
Potential Sources (Municipal and/or Residential)	**Type of Contaminant**
Airports	Acids, Antifreeze, Metals, Petroleum Residue, and Solvents
Centers of treatment of potable water	Acids, Metals, PCBs, and Solvents
Parks	Nutrients, Pesticides, and Sediments
Houses	Bacteria, Nutrients, Pesticides, Petroleum Residue, Sediments, and Viruses
Latrines	Bacteria, Nutrients, and Viruses
Colleges	Creosote, Metals, Pesticides, and Solvents
Highways	Petroleum Residue and Sediments
Stations of public services	Acids, Creosote, Metals, and Solvents
Centers of treatment of water grays/blacks	Bacteria, Nutrients, Metals, Solvents, and Viruses
Potential Sources (Agricultural and/or Rural)	**Type of Contaminant**
Handling of animals	Acids, Bacteria, Microbes, Solvents and Viruses
Agriculture	Acids, Metals, Nutrients, Pesticides, and Sediments
Liquid lagoons and remainders	Bacteria, Microbes, Nutrients, Solvents, and Viruses
Handling of forests	Nutrients, Pesticides, and Sediments
Storage of fertilizers, Pesticides, and petroleum	Nutrients, Pesticides, and Petroleum Residue

Figure 4.12

such as was done in Esteli by the students at National Autonomous University of Nicaragua (Universidad Nacional Autonoma de Nicaragua)/University Center of the Northern Region (Centro Universitario de la Region Norte). Experience shows that certain potential contaminants are often associated with specific activities, land uses, or industries. For example, bacteria in drinking water are generally associated with cattle or human waste, and pesticides are generally associated with agricultural practices. A list of potential sources of contamination in Nicaraguan communities and the associated contaminants is provided in Figure 4.12 developed by the UNAN/CURN students.

There are four main steps involved in identifying potential sources of contamination. At a minimum, Step 1 should be completed. Information collected in Step 1 can be supplemented by completing Steps 2 and 3. Step 4, mapping, is a very important tool to help decision-makers interpret the information collected in previous steps.

1. Review the public records

To begin the process of identifying potential sources of contamination, a search of available public records should be conducted. Municipal or other government-issued maps may show the location of potential sources of contamination like gas stations, automobile repair shops, factories, or wastewater outfalls. Land-use maps can identify areas where non-point sources of contamination such as agricultural runoff and stormwater runoff from roads may be of concern. If available, tax records, land use or property maps, and other government records can be useful in identifying potential sources of contamination.

One of the best resources to help identify potential sources of contamination will be local environmental and water supply officials and agencies. Fire departments, planning officers, health departments and public works departments may have information. The local agency managing the water system may already be aware of activities within the area that threaten the water supply, and may have records of contaminant sources. Students at a nearby university may also be of assistance in identifying and locating contaminants and sources of concern.

Point Sources and Non-Point Sources of Contamination

Some potential contaminant sources are easier to map than others, because they are located at distinct points, while other sources, such as agricultural runoff, occur over a larger area. These two different types of contaminants are referred to as point sources and non-point sources, respectively. Point sources of contamination have a single identifiable location, such as an outfall pipe from a sewage treatment plant. This type of contamination is often easier to monitor, control, and regulate than non-point source pollution. Non-point sources of contamination do not have a single point of origin. Instead, they are diffuse, and include the following:

- *Fields, which contribute agricultural runoff that may contain agrochemicals (pesticides and fertilizers) and/or bacteria from livestock;*
- *Roads, which contribute runoff that may contain metals and oils from vehicles; and*
- *Communities of roofs, which as a whole act as a diffuse source and which can contribute bacterial and inorganic pollutants to surface runoff and infiltrating water during rain events.*

The nature of non-point sources makes them more difficult to control and regulate. However, they are often responsible for the largest amount of contamination in source waters.

Figure 4.13

2. Interview people who know about the area

The people who live and work within the source water protection area can provide very valuable information that may not be found in the public records. Shop owners can provide a wealth of information on the materials and practices they employ. Local inhabitants often make observations that can add to the knowledge of possible contaminant sources in the area. These people may know where a certain outflow pipe is located, or they may be

Inventories of Potential Contaminant Sources for Four Wells in Estelí

Wells Number 9 and Number 19 (Combined Inventory)		
Potential Sources (Commercial and/or Industrial)	**Number of Facilities**	**Types of Contamination**
Residual water	4	Soap, detergent, bacteria, virus, and nutrient
Mill	2	Soap and Detergent
Bread store	5	Detergent and Soap
Illegal Waste	1	Solid Waste
Processing of wood	2	Acids, gasoline, glue, antifreeze, solvents and metals
Mechanics shop	2	Acids, antifreeze, solvents, metals and gasoline
Hair salon	3	Dyes, oxygenated water, permanent, soap, shampoo
Potential Source (Municipal and/or Residential)	**Present? (amount)**	**Types of Contaminants**
Latrines	For all of the population	Bacteria, virus
Residual Water	3	Soap, detergents and chlorine
Colleges	1	Metals, pesticides and solvents
Potential Source (Agricultural and/or Rural)	**Present? (amount)**	**Types of Contaminants**
Handling of animals	2	Bacteria, virus and organic waste

Well Number 14		
Potential Source (Commercial and/or Industrial)	**Present? (amount)**	**Types of Contaminants**
Carpentry factory	2	Soap, solvent and varnish
Saw mill	3	Metals and solid waste
Bus Terminal	1	Metals and oils
Illegal waste	3	Solid waste
Mill	4	Soap and detergent
Tobaco factory	5	Fats, solid waste
Photographic studio	1	Solid waste
Coffee packaging factory	1	Solid waste and oils
Mechanic shop	5	Gasoline, oil, fat and solid waste
Brick floor factory, Laundamat, latrines and tubes	1	Disolvent, oil, dyes, cement, metals
Wooden box factory	1	Fat. Solvent, sellador, glue
Potential Source (Municipal and/or Residential)	**Present? (amount)**	**Types of Contaminants**
Latrines	For all of the population	Bacteria, virus
Causes	5	Bacteria, sediments and solid waste
Houses	All the district	Bacteria, virus, garbage
College	3	Detergents, chlorine and soap
Potential Source (Agricultural and/or Rural)	**Present? (amount)**	**Types of Contaminants**
Handling of animals	2	Bacteria, virus and organic waste

Well Number 8		
Potential Source (Commercial and/or Industrial)	**Present? (amount)**	**Types of Contaminants**
Brick factory	2	Organic Material
Mill	4	Soap and Detergent
Bread store	1	Oil
Illegal waste	3	Solid Waste and Metals
Furniture factory	9	Acids, gasoline, glue, antifreeze, solvents and metals
Mechanics shop	4	Gasoline
Washing of cars	1	Lubricants. Oil, paint
Hair salon	1	Oxygenated Water
Potential Source (Municipal and/or Residential)	**Present? (amount)**	**Types of Contaminants**
Latrines	For all of the population	Bacteria, virus
Residual Water	2	Soaps, detergents and chlorine
Houses	All the district	Bacterias, solid waste
College	5	Chlorine and detergent
Potential Source (Agricultural and/or Rural)	**Present? (amount)**	**Types of Contaminants**
Handling of animals	2	Bacteria, virus and organic waste

Figure 4.14

aware of a certain business's disposal practices or past practices. Local officials are another excellent source of input on public contamination sources.

3. Walk/tour the source water protection area

Perhaps the most useful method to collect information on public contamination sources is by walking or touring the source water protection area and visiting the locations identified as having potential sources of contamination. Talking with the owners/operators, observing their operations, and reading product labels can be very revealing. Foot surveys will also provide verification of contaminant source locations and may unveil additional potential contaminant sources.

Students in Estelí touring the source water protection area.

Students in Estelí collected potential contaminant source inventories for the 16 candidate source water protection areas in their town by walking through the protection areas they had delineated. To compile detailed inventories, they spoke with local business owners, observed local practices, and noted the type and number of potential sources and associated contaminants. Figure 14 presents a sample of four of the inventories from Estelí. The students decided to combine the inventories for Wells 9 and 19 because the protection areas overlapped almost entirely.

4. Map the contaminant sources

Once the potential sources of contaminants in the source water protection area are identified, the final step is to map their location on a source water protection map. An example of a mapped source water protection area in which the potential contaminant sources have been identified is shown in Figure 4.15. The mapped areas should show the public supply well location(s) or drinking water intake locations as well as the potential contaminant sources.

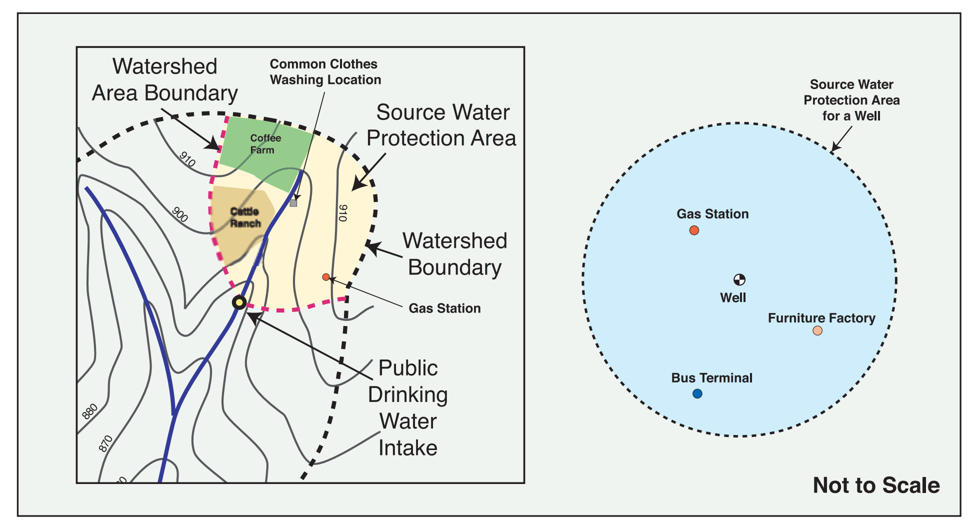


Figure 4.15 Simple example of a source water protection area in which the potential contaminant sources have been mapped.

Protection of source water requires a collaborative community approach. It is therefore critically important to maintain good relationships with all stakeholders even in cases where they may be responsible for release of potential contaminants. This objective should be kept in mind while touring a source water protection area. The process of performing the contaminant source inventory may be a good opportunity to begin a dialogue, with people living and working in the protection area, about source water protection and the connections between health and drinking water protection. Chapter 9 provides more ideas about where to find additional information on the drinking water supply and potential contaminant sources in your town.

4.5 Ranking of Potential Contamination Sources

After all of the major potential sources of contamination have been identified and mapped, ranking of those sources will help to guide the management strategy developed by a community or its representatives. Financial resources available for source water management are commonly limited. Therefore, every effort should be made to direct management efforts to the most important locations and the most harmful contaminant sources. Ranking the threats from each potential source of contamination based on the magnitude of the threat, allows for development of an efficient management strategy.

Ranking Matrix of Potential Sources and Contaminants

Source	Contaminants	Proximity to Well[a]	Travel Time to Well[b]	Quantity of Contaminant[c]	Natural Degradation[d]	Total Rank (Average)
Bus Terminal	Oil and grease	4	4	5	4	4.25
Gas Station	Oil and grease	4	4	5	4	4.25
Open Defecation	Bacteria	4	3	5	2	3.5
Cattle grazing	Bacteria	2	2	5	2	2.75
Furniture Factory	Solvents, oil and grease	2	3	2	4	2.75

a) 1 = far, 5 = close
b) 1 = long time, 5 = long time
c) 1 = small, 5 = large
d) 1 = very rapid, 5 = slow

Figure 4.16

Ranking of potential sources of drinking water contamination can be performed, as is done in the United States, for example, by the entity responsible for delivering water, or by the local health or sanitation board. Ranking can also be done by a committee or by a group that represents the various stakeholders in the protection area. The ranking of contamination sources provides an important piece of information for the source water managers and stakeholders. It is from this ranking that members of the public are able to contribute informed input on planning protection activities. Source water managers can look at a list of priority sources of contamination and decide upon appropriate actions to protect drinking water sources from contamination. The basis for ranking contaminants is the decision of and overseen by the Source Water Management And Planning Committee (see Chapter 5). It is useful to develop a simple matrix to compare the threats of public contaminant sources. Some may be more harmful to human health than others. Some may be easier to control and/or cheaper to manage than others. Some may be reaching the water supply in greater concentrations than others. Proximity of the contamination source to the water resource, the type of contaminant, the quantities of hazardous materials on a property, travel times and natural degradation of chemicals, and management practices of the owner/operators are also important considerations. Figure 4.16 shows an example of a basic ranking matrix that might be developed by a community in Nicaragua.

One fundamental consideration in ranking potential contaminant sources is the relative amount (or "load") of pollutant, which might be generated by each source within the watershed. For example, one source might be cattle (a non-point source of contamination). If cattle have free access to a river that serves as a water supply, the potential nitrogen load from those cattle could be estimated. If it is known that there are 80 head of cattle grazing in the source water area within close or direct proximity to the river, and each head of cattle generates approximately 73 kg of nitrogen per year in manure (Lander, et al., 1998), the loading of nitrogen can be estimated at 5,840 kg/yr from the cattle.

Representative Values for Nitrogen Loading Rates for Various Sources

Land Use	Loading Rate
Atmospheric Deposition on Forest Land[a]	6.4 kilograms/hectare/yr
Atmospheric Deposition on Agricultural/rural Land[a]	13.3 kilograms/hectare/yr
Atmospheric Deposition on Urban Industrial Land[a]	21.2 kilograms/hectare/yr
Latrine[a]	2.5 kilograms/person/yr
Cattle[b]	73 kilograms/animal/yr
Horse[b]	54 kilograms/horse/yr
Agriculture[a]	4.9 – 8.9 kilograms/hectare/yr
Pasture[a]	14.6 kilograms/hectare/yr

a) Source: EPA. 1999. Tools for Watershed Protection: A Workshop for Local Governments. Prepared by Horsley & Witten, Inc. for US EPA, Office of Wetlands, Oceans and Watersheds.
b) Source: MA DEP. No Date. Massachusetts Department of Environmental Protection. Nitrogen Modeling. Prepared by Horsley & Witten, Inc. for the MA DEP, Division of Water Supply.

Figure 4.17

Based on that estimate, the cattle farm could be ranked in a matrix against other sources in terms of importance and potential impact to the water supply. A cattle farm with cattle roaming in the river would likely be given a high rating, perhaps a 5 on a scale of 1 to 5 (5 being of greatest concern), since it has the potential for major negative impacts to water quality. However, if the same number of cattle are restrained from access to the river, and direct flushing of cattle urine and feces into the river are mitigated, that source of contamination would likely receive a lower rating, perhaps a 2 or 3, as it does not pose as great a threat to water quality. Similar methods can be used for other potential non-point pollutant sources, such as pesticide use on agricultural lands or fecal bacteria from humans and cattle in the source water protection area.

A point source of contamination like a sewage outfall pipe might receive a rating of 5 if the discharge were close enough to a water source as to pose a serious threat to water quality. However, it might receive a 3 if the sewage is treated before being released and if it is located on the outer perimeter of the area of contribution to a water source. Contamination sources that might receive a ranking of 1 or 2 would be perhaps a hair salon that utilizes small quantities of hazardous materials, a small chemical user that complies with waste disposal guidelines or regulations set by the environment ministry, or a coffee farm, if it were organic and treated its coffee processing waste.

4.6 Conclusion

Source water assessment includes all the steps outlined in this chapter: delineation of the SWPA, inventory of potential contaminant sources, and ranking of those sources. These steps lay the foundation for the development of a management plan to protect the source water area. Stakeholders can then play a vital role in determining what actions might be most effective to protect and manage the drinking water sources. A guide to developing a management plan is presented in Chapter 5. The key to success of a source water management plan is to provide a mechanism for the general public to participate in the development and implementation of the management plan. A primer on public participation in source water management is provided in Chapter 6.

The next step in source water protection is to develop a program to include the public in shaping a community source water protection plan.

5 Developing a Community Source Water Management Plan

5.1 Introduction

Once the Source Water Assessment (Chapter 4) has been completed, a management plan can be developed to protect the community's drinking water sources. This chapter describes activities that are essential in establishing an effective source water management plan, including:

- assessment of the current management of local drinking water;
- development of a consensus-based management plan;
- identification and selection of a set of management tools to help carry out the source water management program;
- coordination of source water protection with centralized treatment, and
- exploration of local management options.

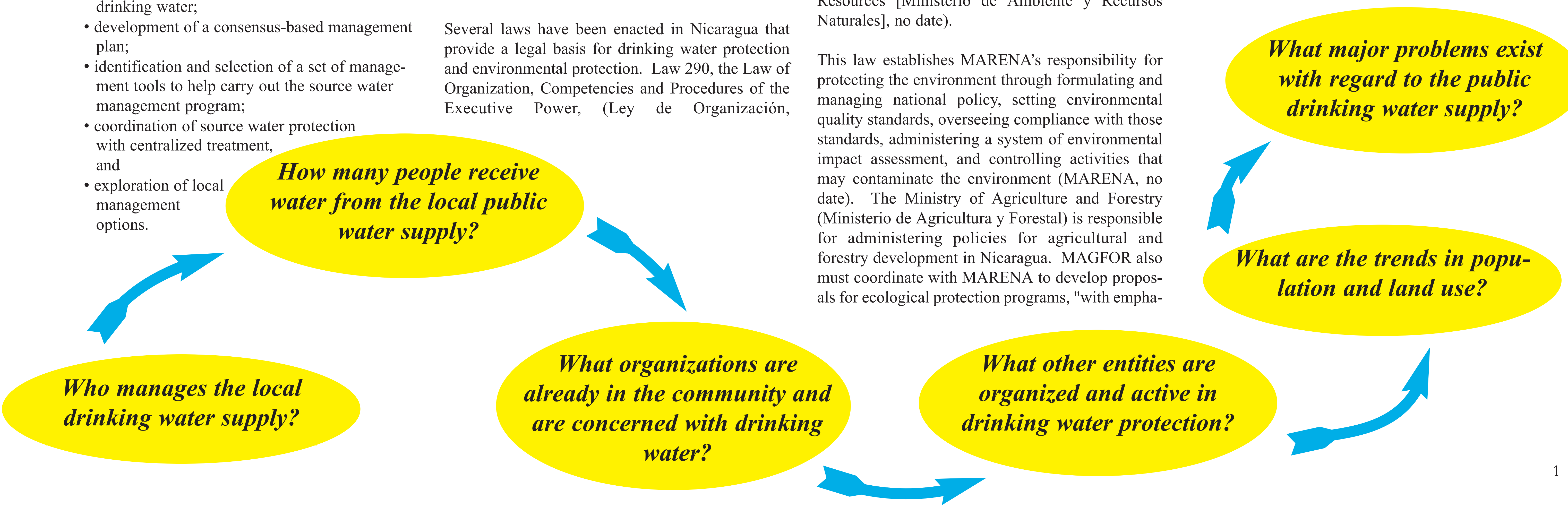
Before developing a source water management plan, it is important to understand the legal basis for watershed protection and drinking water protection that already exists in Nicaragua.

5.2 A Review of the Existing Legal Framework for Source Water Protection and Management in Nicaragua

Several laws have been enacted in Nicaragua that provide a legal basis for drinking water protection and environmental protection. Law 290, the Law of Organization, Competencies and Procedures of the Executive Power, (Ley de Organización, Competencias y Procedimientos del Poder Ejecutivo, 1998), outlines the responsibilities, including those pertaining to environmental protection, of all national government agencies. In accordance with this law, several national agencies are accountable for various aspects of environmental protection, environmental monitoring and natural resource use (Ministry of Environment and Natural Resources [Ministerio de Ambiente y Recursos Naturales], no date).

This law establishes MARENA's responsibility for protecting the environment through formulating and managing national policy, setting environmental quality standards, overseeing compliance with those standards, administering a system of environmental impact assessment, and controlling activities that may contaminate the environment (MARENA, no date). The Ministry of Agriculture and Forestry (Ministerio de Agricultura y Forestal) is responsible for administering policies for agricultural and forestry development in Nicaragua. MAGFOR also must coordinate with MARENA to develop proposals for ecological protection programs, "with emphasis on the conservation of soils and water (MARENA, no date)." The Nicaraguan Aqueduct and Sewer Company (Empresa Nicaraguense de Acueductos y Alcantarillados) is responsible for providing potable drinking water and sanitation services nationally. It has a division called the Rural Areas Division of the Nicaraguan Aqueduct and Sewer Company (Empresa Nicaraguense de Acueductos y Alcantarillados – División de Areas Rurales) that is responsible for rural areas. The Ministry of Health (Ministerio de Salud) promotes environmental health and good hygiene among the population, formulates standards for hygiene and environmental health, and controls the quality of water for human consumption.

The law most directly pertaining to drinking water protection is Law 217, the General Law of the Environment and Natural Resources (Ley General del Medio Ambiente y los Recursos Naturales) (published in the Diario Oficial in 1996). This law established MARENA's responsibility for regulating and



setting national environmental standards. Title III outlines MARENA's responsibility to carry out environmental laws and uphold natural resource use standards. Title IV addresses environmental laws and standards for environmental quality and the control of contamination of air, water and soil.

Another law, the Disposiciones Para el Control de la Contaminación Proveniente de las Descargas de Aguas Residuales Domésticas, Industriales, y Agropecuarias, Decree Number 33-95, was passed in 1995 in an effort to control contamination of water from various discharge sources in Nicaragua. This law sets maximum limits on various contaminant concentrations in the discharge of different categories of household, industrial and agricultural wastes into sewer systems and surface waters. Implementation of Decree Number 33-95 falls under the jurisdiction of MARENA.

Municipalities also share in the responsibility for environmental health and drinking water protection as outlined in the Ley de Municipios (Ley 40 and 261) (MARENA, no date). They are responsible for rational use and conservation of natural resources, developing local initiatives for environmental protection, and contributing to national efforts to monitor and control environmental quality.

Municipal officials, local representatives from MAGFOR, MINSA, and MARENA, and local leaders from NGO's meet in Ocotal, Nicaragua to discuss the local source water protection project.

Together, these laws provide legal environmental framework to support development and implementation of a national program or network of programs for source water protection in Nicaragua. Because the number of government entities tasked with protecting, monitoring and using natural resources in Nicaragua is large, coordination is suggested. Designating a lead agency for source water protection is often helpful for organizing discussion and actions toward source water protection, as discussed in later sections of this chapter.

5.3 Assessing the Current State of Drinking Water Management in a Community

The development of a source water management plan should begin with an assessment of the current status of local drinking water management and local watershed management programs. It should then build upon the programs and institutions already in place within the community. Therefore, the first step is to examine the existing management structure and identify the organizations involved. The answers to the following questions will facilitate an assessment of the current approach to management of the local drinking water supply:

- Who manages the local drinking water supply? Is it a local water utility, such as AYAMAT in Matagalpa, a national water utility, such as ENACAL, or some other entity?
- How many people receive water from the local public water supply? Where do they live? Who lives in the source water protection area, and do they all receive water from the public water supply?
- Who works or lives in the source water protection area that does not utilize the public water supply?
- What existing local, regional, national and international institutions and organizations are concerned with drinking water, public health and/or environmental resources and are active in the community?
- What other entities in the community are organized and active and could become involved in drinking water protection?
- What are the trends in population and land use within the source water protection area?
- What major quality and quantity problems exist with regard to the public drinking water supply?
- What problems can be expected in the future?

In researching the answers to these questions, it will be necessary to talk to the mayor's office, the health department, MINSA, the ENACAL office, and various other agencies, individuals, and organizations in the community. The goal of this step is to understand the current management arrangements so that a new effort to protect source waters can build upon the system that already exists. This assessment will also help determine where there may be strengths and weaknesses in the current management structure, which will help direct development of the management plan.

5.4 Developing a Consensus-Based Source Water Management Plan

Once the current state of drinking water management is documented, efforts to develop a management plan for drinking water sources can be initiated. One key to developing and implementing a successful drinking water source management plan is involvement of the local government. The Mayor's office should be involved in the development of the plan, and the Mayor should be briefed on the source water protection issues. The involvement of municipal departments is also recommended, for example the Planning Department (where zoning may be administered) and the Health Department (where water quality monitoring may be coordinated).

Another key to a successful source water management plan is involvement of stakeholders and community members. Both of these groups should be permitted and encouraged to participate in the development of the management plan. These groups include people who not only drink the water and benefit from a clean source of water, but can also affect the quality, and even the quantity of the water supply. Management plans depend to a significant degree on public and stakeholder support and participation. Without the input and support of both stakeholders and community members, a management plan may overlook or incorrectly address important issues, and may therefore be extremely difficult to put into practice.

There are several steps that should be followed in developing a community-based source water management plan. These efforts build on the information that has already been collected in the Source Water Assessment (Chapter 4), the public participation phases of the program (Chapter 6), and the assessment of current source water management (described above).

Steps to a Source Water Management Plan

1. **Initiate the Source Water Protection Process**
2. **Form the Source Water Management Planning Committee**
3. **Define Collective Management Goals**
4. **Define the Time Frame of Your Management Goals**
5. **Develop a List of Management Options to Achieve the Management Goals**
6. **Determine the Primary Implementing Body for the Plan**
7. **Choose Management Tools and Develop a Detailed Management Plan**
8. **Review and Update Management Plan**

Figure 5.1

5.4.A. Initiate the Source Water Protection Process. Developing a source water management plan is most likely a combined effort among the local, regional, and national governments, stakeholders such as industries and NGO's, and community residents. From experience with the pilot projects in Estelí, Matagalpa and Ocotal, it is clear that clean drinking water is a prime concern among people in the communities. The idea of a long-term program to manage and protect drinking water sources has met with positive responses in these pilot project towns. Such a program, however, requires leadership to initiate it and strong management to carry it out.

At the local level, a source water protection program can be initiated by the entity that has legal authority to do so, which may be the office of the Mayor. Leadership for the program can come from municipal and/or quasi-municipal departments with personnel that understand the circumstances surrounding source water management within their specific community, including general land uses, social and health concerns, and economic issues.

As discussed in Section 5.3, the local source water protection effort should build off of the existing institutional structure within each city. The institutional structure of each city can vary, and each may be slightly different. 'Institutional structure' refers to the variety of agencies that play a role in day-to-day city management. Examples may include:

- departments within the Alcaldía;
- educational institutions present in the city;
- non-governmental organizations functioning in the town;
- multilateral and bilateral aid projects established in the town;
- health centers; and
- the drinking water management agency.

5.4.B Form the Source Water Management Planning Committee. A fundamental component of a source water protection program is establishment of a committee to write a source water protection plan and assist in its implementation. The entity with the legal authority to initiate source water protection in the community should draw on local human resources to form a committee on source water management. The committee can then be charged with the responsibility to develop the plan. There are several options for the composition of this Source Water Management Planning Committee. It can be made up of stakeholders, health professionals, water utility managers, or some combination of these groups. This committee should, with oversight from either the local government or the local water utility, take the lead in development of a local source water management plan. Part of the Source Water Management Planning Committee's role should be to organize a forum, such as a series of public meetings, for public participation and input in the development of the management plan (see Chapter 6: Public Participation). The local government, with the support of the committee, can also work with other local governments, and the national government (probably ENACAL in the case of Nicaragua) to develop the appropriate structure for a national source water protection program.

Who are 'Stakeholders'?

Any specific interest group, company, or organization that is affected by water quality, affects water quality, or may be affected by the management of a source water protection area falls into the stakeholder category. This list will likely be quite long for any given protection area. For example, local associations of cattle ranchers or coffee growers as well as student environmental awareness groups might all share a specific interest in the quality and management of the drinking water source, and should all be considered stakeholders. Just as the general community's input is integral to the success of the management plan, so is the input of all stakeholder groups in a source water protection area.

Figure 5.2

Initiation of Source Water Protection in Ocotal

At the initiation of the Ocotal pilot project, representatives from the Mayor's office brought together a group of stakeholders to discuss source water issues. This group could become the basis for a source water management planning committee. The participants at the meeting included a wide variety of non-governmental and governmental organizations involved in drinking water and health issues in Ocotal. The attendees represented the following organizations:

- Movimiento Comunal (Community Movement)
- Association of Women in Development (AMDES)
- INAFOR
- MARENA
- MAGFOR
- World Relief/ Auxilio Mundial
- MINSA
- High School of Biologists and Ecologists of Nicaragua (COBEN) – Ocotal
- Office of the Mayor (Alcaldía)

5.4.C Define collective management goals. An effective source water management plan must have a clearly-stated set of goals. Different stakeholders or stakeholder groups may prefer different management goals. Members of the public may also other viewpoints. It is critical that the process of establishing goals be done in a manner that builds consensus. In some localities, the management goals may be quite clear, but in most cases, this step can be expected to require significant discussion. Management goals should be defined in measurable terms. Clear goals provide strong guidance for developing management options, and allow accurate assessment of the effectiveness of the management plan over time.

All interested stakeholders and members of the public should have input into defining the source water management goals, and every effort should be made to get as many affected people involved in the decision-making as possible. A recommended forum for discussion is a well-publicized, open public meeting. The broader the involvement of stakeholders and the public in this process, the more likely the plan is to succeed.

A meeting of stakeholders in a small source water protection area in northern Nicaragua may have an invitee list as follows:

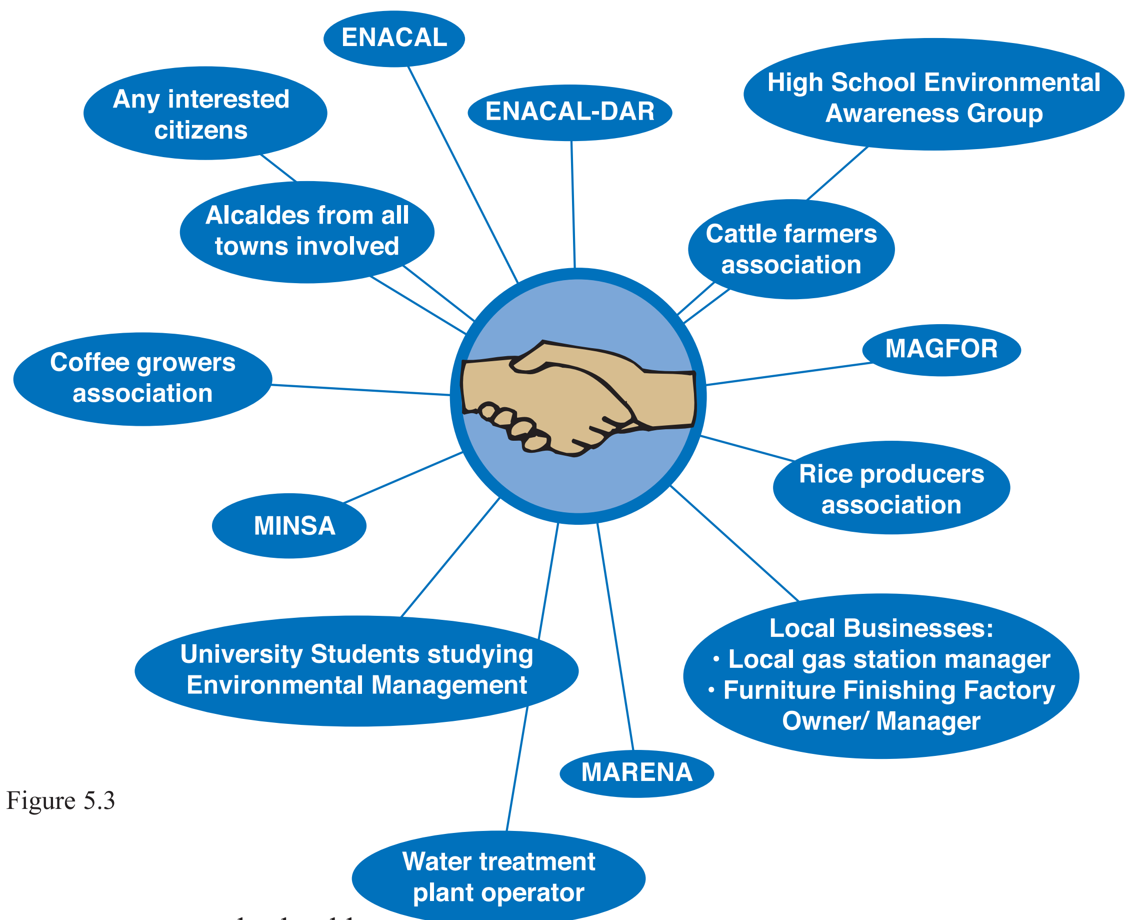


Figure 5.3

The substance of the management goals should be driven primarily by the source water assessment for the protection area (Chapter 4) and by the input of stakeholders and the public. It is important that stakeholders and the public are made aware of the assessment information so that they have all the necessary information to engage in an informed discussion. A management goal may be based on achieving better water quality, for example, reducing fecal coliform bacteria to a certain level at the drinking water intake or reducing the concentration of nitrate to a specified level. Alternately, a management goal may be defined using human health parameters, such as a 50% reduction in the incidence of diarrhea in children. Management goals may also address uses of land and water, such as reducing the number of cows roaming in the river by 75 %, or increasing the use of latrines by permanent and seasonal residents in the watershed by 90 %.

5.4.D Define the time frame of the management goals. Another important component of the source water management plan is the time frame in which the goals are to be reached. It is common to have both short-term and long-term management goals. Using examples from Section C above, a short term management goal may be a documented increase in the use of latrines; a medium term goal could be a numerical reduction in the number of cows with free access to rivers; and a long term management goal may be a measured improvement in water quality. An example timetable is shown in Figure 5.4.

5.4.E Develop a list of local management options to achieve the management goals.

While energy, interest and support from the community and stakeholders is essential to a program's success, management of a source water protection program is generally a joint venture between the national and local government. On the national level, the agency in charge of drinking water management, for example, ENACAL, would be the most likely and logical agency to oversee the program. Collaboration with the Ministry of Health is necessary to appropriately address the human health risks from the drinking water contaminants of concern. The national government will also benefit from local collaboration in the local assessment and implementation of a national source water protection program. However, a national framework for source water protection would provide additional needed financial, legal, technical and organizational support from the national government.

Municipalities can use their local regulatory authority to promote source water protection by employing one or a combination of tools, such as:

- Incorporate watershed management costs into the local water rates to cover some costs associated with the source water protection program. Local water management agencies, such as AYAMAT in Matagalpa, or the local offices of ENACAL could include a very small fee within the water rates specifically for watershed management efforts, such as public education or construction of community wash stations.
- Develop zoning regulations for specified land uses within source water protection areas. For example, in a town that depends primarily on ground water, such as Estelí, it may be helpful to develop a zoning map based on the source water protection areas for the wells that would exclude certain risky commercial and industrial land uses from those areas.
- Develop a framework for conservation easements to conserve natural lands in protection areas. For example, a local non-profit organization may be interested in conserving some natural land for ecotourism, environmental health and/or source water protection. By providing a framework for easements to be instituted, the likelihood of the land actually being protected is increased.
- Provide tax incentives (and reduce disincentives) for improvements in land use, household and industrial practices and the use of innovative and alternative technologies that reduce source water contamination. For example, there is currently an improvement tax levied on coffee farmers that build coffee husk collection basins. These basins allow coffee farmers to ferment the husks into fertilizer rather than disposing of them directly into surface waters. Conversely, a tax break would actually provide more incentive for coffee farmers to invest in these basins.

These tools and others are described in more detail below. In general, management tools fall into one of two categories: regulatory and non-regulatory.

Example Management Goals and Target Dates for a Source Water Management Plan

Management Goal	Target Date
Increase use of latrines to 90% of population	1-3 years
Reduce fecal coliform counts at drinking water intake by 75%	3-5 years
Reduce annual incidence of diarrhea in children by 50%	3-5 years
Reduce the number of cows grazing directly in the river by 75%	3-5 years

Figure 5.4

Regulatory Tools:

Regulatory tools may include zoning, health regulations, performance standards and best management practices. These may not currently exist, but are worthy of consideration.

• Zoning Regulations. The purpose of zoning is to separate incompatible land uses by assigning different areas for each use (e.g., commercial, residential, industrial, agricultural) and setting standards for the uses permitted in each zone. A zoning board of the local municipal government usually determines zoning regulation. Under the umbrella of zoning regulation, the type of land uses, the density of land uses, and the allowable practices for each land use type can be regulated. For example, a zoning map could be used to regulate agricultural practices in a given area such that pesticide use in that area may not exceed a prescribed level. Similarly, certain types of industry that pose high risks to water quality may be prohibited in identified source water protection areas around drinking water wells.

• Health Regulations. A health regulation can be adopted by a municipality to protect drinking water. Health regulations can include prohibition of dwellings and latrines within a buffer area around a well or surface water intake or prohibition and control of the use of certain pesticides in a delineated source water protection area for a drinking water intake or a well.

• Performance Standards. A local health or water board may impose a requirement that any water discharges to the ground or to a surface water body must meet certain water quality limits. For example, a surface water discharge may be required to have undetectable levels of bacterial contamination, low nutrient concentrations or limited levels of metals and organic chemicals.

• Best Management Practices. A community regulatory authority could require residents and businesses to employ certain techniques called best management practices (BMPs), to minimize the discharge of pollutants into drinking water sources. Examples of BMPs might include fencing of livestock away from surface waters, regular removal of solids in latrines, and the use of infiltration basins to minimize contaminant loading to surface waters from storm water runoff.

• Tax Breaks. Tax breaks from the local or national government may help to promote positive source water protection improvements and actions among individuals and companies. For example, tax breaks could be awarded for improvements such as pretreatment of discharge water from industry or improved on-site land use management, or for a contribution to a public education campaign.

Non-Regulatory Tools:

Non-regulatory management tools can be very effective in protecting drinking water by providing information and opportunities for involvement.

• Education. Public education campaigns can be carried out by many different groups in a community, depending on the interest and resources of those groups. Educational efforts are often an effective way to spread the word about issues, especially in cases where general awareness is low. For example, as part of the Ocotal pilot project, students in a local environmental brigade carried out an educational campaign to teach coffee workers, coffee farm owners, and cattle ranchers about the connection between their activities, various land uses, the quality of the water they drink, and their personal health.

• Conservation Easements. Conservation easements are land use rights that are turned over from a private landowner to a town, national government, individual or conservation group in exchange for some financial reward, usually in the form of a tax break. The owner of the land retains title to the property, but gives up the right to develop that land.

The use of conservation easements for ecological and natural resource conservation in Latin America is a relatively new and exciting practice. The first Latin American conservation easement (servidumbre ecológica) was instated in 1992 in San Ramón de Tres Ríos, near San José, Costa Rica after the idea was introduced to Central America by the Iniciativa para la Conservación de Tierras Privadas de Centro América (Mack, 1997). Since then, over 35 conservation easements have been negotiated throughout Central America and Mexico (Charney, 2000).

Conservation easements can protect vital source water areas. In some cases, a conservation easement can open a natural area to use by the public for low-impact activities such as hiking while still maintaining ecosystem integrity. Easements can be a useful tool for protecting undeveloped

Source Water Management Tools and Possible Implementing Agencies

Management Tools	Possible Implementing Agency
Regulatory	
• Zoning Regulation	Zoning Board, Office of the Mayor
• Health Regulation	MINSA, Office of the Mayor
• Performance Standards	MINSA, ENACAL, MARENA
• Best Management Practicies	Office of the Mayor, MARENA, MAGFOR
• Tax Breaks	Office of the Mayor, ENACAL, National Government
Non-Regulatory	
• Education	Office of the Mayor, School Group, ENECAL, MINSA, Non-Governmental Organization
• Conservation Easement	Office of the Mayor
• Water Quality Monitorings	School Group, ENECAL, MINSA, Non-Governmental Organization, MARENA
• Local Drinking Water Management	ENACAL, Office of the Mayor
• Economic Incentives	National Government, Municipal Government

Figure 5.5

areas within a source water protection area around a well. However, the benefits to the landowner must be significant and there must be enough confidence in legal land rights structures to ensure that the easement will be upheld in perpetuity.

• Water Quality Monitoring. Monitoring the quality of source water is a very useful and important management tool. Monitoring allows a community to identify water quality issues and track the successes and failures over a period of months or years. It also enables a community to identify water quality problems as they arise. An important part of source water protection is monitoring the quality of the water supply at different points in the delineated source water protection area. Ongoing water quality monitoring allows the community to recognize threats to drinking water and identify contaminant sources. It allows rapid identification of contaminants and enables timely response. Monitoring programs can be expensive, but a collaborative approach that utilizes local funds, volunteer aid, and national support can make a comprehensive monitoring effort economically feasible.

Water quality data can be useful not only to a specific source water protection program, but also for universities, environmental and other non-governmental organizations, health officials, and local or national government entities interested in further study of water quality related issues. Water quality monitoring can be carried out by a national agency, such as MINSA or ENACAL, by the local municipal government, or by local citizen groups, which can be extremely effective. While laboratory services are not accessible to most communities in Nicaragua at the present time, affordable water quality monitoring kits are available from several companies. These test kits generally allow field-testing of pH, temperature, nitrates, fecal or total coliform bacteria, and some metals. Therefore, the water quality results can be obtained rapidly in the

Monitoring the quality of source water is a very useful and important management tool

Figure 5.6

Water Quality Sampling Field Data Sheet

Stream (Well) Name/Number: ____
Watershed Name: ____
Municipality: ____
Department: ____
Geographic Location: ____
Sampling Site Name and Number (if any): ____
Physical Description: ____
Investigators: ____
Date: ____
Time: ____

Weather in the Past 24 hours: ____
(storm, rain, showers, overcast, clear/sunny)

Current Weather: ____
(storm, rain, showers, overcast, clear/sunny)

Comments: ____

Sampling information:

Sample Number	Parameter	Field Measurement

field rather than requiring water quality tests to be performed in a laboratory. Laboratory water quality testing on a routine basis may be expensive and/or logistically difficult due to travel between the sample location and the laboratory.

When taking water quality samples, it is important to properly document the sampling process and sampling conditions for future reference. An example of a basic water quality sampling field data sheet that could be used for documentation is presented in this chapter.

• Local Drinking Water Management. Another non-regulatory tool is the establishment of a local water control or authority (for example, AYAMAT in Matagalpa) (see Figure 5.7). Local control of the water source and water treatment and distribution system can be beneficial to the community because a local board may be able to react to local needs more directly and rapidly than a national agency.

• Economic Incentives. A final tool that can be considered under the non-regulatory framework is the development of economic incentives to encourage landowners and businesses to take action to protect water quality. This may be in the form of a government grant or favorable financing for loans to make improvements that help to protect source water. Examples of positive improvements include a settling basin for recovering coffee husks, construction of a biodigestion chamber for coffee processing discharge water treatment, or construction of a community clothes washing station. Government grants could also support public education campaigns on local source water protection.

5.4.F Determine the primary implementing body for the plan. In order to implement the management plan effectively, there must be a managing body to oversee the effort. This agency would take the lead on actions contained in the management plan. It would also coordinate with other agencies and organizations to implement each management tool and monitor success. Depending on the tool, coordination would take place between the lead agency and another government body, such as MINSA, MARENA, MAGFOR, ENACAL, the Alcaldía, or a local water board, or a local organization, such as a school, a non-governmental organization, or a local association. In some cases, a new group could be formed for the purpose of implementing one or more of the management tools. Figure 5.5 presents the source water management tools discussed in the previous section and the possible implementing agencies.

5.4.G Choose management tools and develop a detailed management plan. The final step in the management plan process is to assemble all the plan components into one concise document that is made publicly available. The final management plan will likely include a set of management tools to achieve between one and four management goals in a given time frame. The set of tools could be chosen with stakeholder input at a public meeting or hearing in which the benefits and drawbacks of the tools are presented to the public. A variety of criteria could be used to decide on which tool to use to address a given source water problem. Some tools might be more easily implemented than others, some might address the problem faster than others, or some might be less expensive to implement than others.

The goals (discussed in Section C) should be very clearly stated at the beginning of the plan. The plan should document stakeholder and public concerns, and identify who is responsible for implementing each management tool in the plan. Before finalizing the management plan, it is generally a good idea to make the final draft available to stakeholders and the public for a comment period. This will provide all stakeholders and the public with the opportunity to review the plan, express any concerns and have those concerns addressed before the plan is finalized.

During development of the management plan, there are several important issues that should be kept in mind. Managing a drinking water source is not a static process, but an anticipatory (and dynamic) task. Because conditions change with time, there should be provisions in the management plan to deal with unpredictable shifts in conditions and/or priorities. It is recommended that the following points be addressed in the planning process:

- Plan for new water sources in addition to those already in use. A growing community will need to look for alternative sources of water. Identifying potential future drinking water sources allows the community to protect those sources for future use. Protection may involve special zoning or limited land uses in areas around possible future wells, and may help to direct the pattern of development to ensure a safe drinking water supply in the future.

- Develop a contingency plan. It is a good idea for the community to have a contingency plan for alternative drinking water sources. Even with a proper management plan, accidents can happen and a primary drinking water source can become contaminated or a water treatment facility can be disrupted. For example, if ground water is the main source of drinking water, having a large storage tank filled at all times, which could be used in an emergency, might be appropriate. In other situations, it may be appropriate to close off a contaminated ground water well and draw drinking water from alternative wells. To the extent possible, a community should have a plan to warn citizens of a contamination incident, provide an alternative drinking water source, repair problems in a water treatment facility, remove the source of contamination, and treat the contaminated water so that it can be returned to use.

Local Water Agency

An example of a local water agency in Nicaragua that appears to be achieving management success is AYAMAT (Acueductos y Alcantarillados de Matagalpa). AYAMAT is a semi-private spin-off from ENACAL in Matagalpa, established in the 1990s. AYAMAT is managed similarly to a private company but also works in cooperation with ENACAL. It has been successful in managing the issue of limited water quantity in the city of Matagalpa. AYAMAT has been working with the local Mayor's office and the local watershed protection project Proyecto Cuencas Matagalpa to carry out better water supply management for the city and surrounding areas.

Figure 5.7

5.4.H Review and Update Management Plan. Ensure flexibility in your management plan. Because the future can rarely be predicted, flexible management is a critical characteristic of an effective drinking water protection program. Conditions in the community may change, and the plan that is developed today may not be the best plan three or five years from now. In order to build flexibility into the source water management, the planning committee should continue to meet periodically to monitor the implementation and effectiveness of the management plan, and to update and adjust the plan to address changing conditions and concerns. In addition, the committee should continue to maintain an open dialogue with stakeholders and the general public, most likely through open informational meetings or newspaper announcements.

5.5 Water Supply Treatment in Conjunction with Source Water Protection

The first defense in providing potable water to an entire community is adequate protection of the drinking water resource itself. Once a drinking water source is contaminated, especially a ground water source, it can be extremely difficult and costly to clean. Many pollutants, especially some synthetic chemicals, are very persistent and cannot be broken down easily in nature. In many cases, only a relatively small amount of pollutant can contaminate a large volume of water. Effective protection can keep treatment costs relatively low and provide more people with access to clean water. However, comprehensive protection of drinking water sources is a long-term process, and may not always succeed. In that case, communities must treat their drinking water, as is currently the case throughout Nicaragua.

In general, treatment of surface water supplies provided at centralized treatment centers involves filtration, flocculation, and chlorination. The drinking water treatment process is generally effective in the removal of bacterial contamination, sediments, and many contaminants that adsorb onto sediments, including pesticides and other organic compounds. Ground water treatment is usually less extensive because ground water sources are usually less prone to contamination, especially by bacteria. Ground water is naturally filtered as it infiltrates through the ground and reaches the aquifer, so it generally has fewer contaminants than surface water. Treatment of ground water often ranges from no treatment to simple disinfection, usually by chlorination. However, typical treatment regimes for surface and ground waters are only marginally effective in the removal of dissolved contaminants including organic compounds, metals and nutrients.

Source water protection therefore plays a key role, not only in improving raw water quality for people who obtain their water before it is treated, but also in reducing human exposure to harmful chemicals and constituents that are not removed in the treatment process. Many people in rural areas where centralized potable water systems are unavailable drink water taken directly from a stream or river. For these people, source water protection is likely the only line of defense against certain forms of contamination, such as microbes or pesticides, in their drinking water.

A management plan can be used to prevent contaminants, including those that are difficult to treat, from ever reaching the drinking water source in significant concentrations. Bacteria and sediment that can usually be handled by a treatment plant at moderate levels can, in excessive amounts, overload the plant, requiring longer treatment time and more intense chlorination. Sometimes a treatment plant is unable to sufficiently remove high amounts of contaminants in the intake water. Decreased levels of contamination entering a treatment plant can help to maintain a more dependable contaminant removal process over a longer period of time.

Time Frame for Developing a Source Water Management Plan

The time frame for development of a community source water protection plan should be approximately one year. A typical schedule is as follows:

- initiation of source water management program (one month)
- formation of the source water management planning committee (one month)
- organization of first public meeting (one month)
- compilation of public comments (one month)
- development of draft management plan (four months)
- public comment on draft plan (one month)
- revisions to draft plan (two months)
- presentation of final plan (one month)
- review and updating of source water management plan (periodically)

Figure 5.8

5.6 Local Management of Water Supplies

Direct local management of water supplies is not common in Nicaragua. Other countries, including the U.S., have shown that local management can allow for more responsive management, and create the opportunity for collaboration among local agencies. For example, a local water agency can work with the municipal planning office, the local tax office and other local offices to adapt health and land use regulations and community management plans for better source water protection. A local water agency can underwrite costs by collection of water use fees. Consequently, a local water entity can be run more like a business than a public agency, with efficient operation and maintenance and more dependable service. This capacity can have important implications for the health of a community.

6 Public Participation - A Primer



Protecting the quality of drinking water begins with people.

6.1 Introduction

Protecting the quality of drinking water begins with people. The people who live in the watershed area of a drinking water intake or in a zone of contribution to a well have a very important role to play. The kinds of things they do on a daily basis have a direct effect on the quality of drinking water. The more people understand their role in both protecting and impacting water quality, and the more they participate in taking action to safeguard water quality, the better the management of the water resource, and the better the health of people in the community. Therefore, public participation is the most critical element of a successful source water protection program. Without a comprehensive, well-planned effort to include the public in development and implementation of a source water management plan, it is unlikely that the program will be successful.

"Why should I protect the public drinking water source if I don't drink water from that source?" People who live in the watershed area of a public drinking water intake or zone of contribution of a well but who do not receive treated water delivered from that intake or well might wonder why they should take action to protect the quality of that water. By protecting the greater source water area, which may also include streams, rivers or wells where they get their own water, people also protect their own water quality and their own health. They will also be contributing to the environmental health of the area. Similarly, a business that operates within a source water protection area, but may not use the public water supply, should take action to prevent possible contamination of public drinking water sources for the benefit of their customers and workers who do use public water.

Figure 6.1

6.2 Seven Components of Successful Public Participation

Public participation is the process by which all interest groups (stakeholders and the general public) in a community are provided the opportunity to make their views known on drinking water issues and protection, and to contribute to designing a drinking water source protection plan. An effort must be made to include the full range of community opinion in discussion of approaches to protection of drinking water sources so that all issues are brought to light and an appropriate and workable source water protection strategy can be developed.

Public participation is important to source water protection because it:

-Builds networks among key individuals in a community who will implement source water protection measures,
-Identifies needs and priorities with respect to source water protection in the community;
-Provides education and information to all residents of a community;
-Focuses public attention on the issue of source water protection;
-Sets up a framework for community support of protective action;
-Builds momentum for the program; and
-Provides the benefit of input and experience from a broad cross-section of the community.

Public participation has many components, all of which should be considered when developing a source water protection plan. These components potentially include direct involvement of stakeholders in the source water management planning committee (see Chapter 5), involvement in general public informational meetings through submission of written and oral comments, and participation in community events such as art contests and demonstration projects. Additional components include development and distribution of educational products that target the public at large, for example fact sheets, posters, radio ads, brochures, and artwork.

Public participation is the process by which stakeholders make their views known.

There are seven main components to a successful public participation effort:

1. <u>Public Introduction to Local Source Water Issues</u>

A general public meeting can be a very effective way to introduce the issues relating to the local drinking water source, such as existing and potential problems with contamination of source waters and the impacts that contamination may be having on public health. Assuming that local government will take the lead on source water protection and management in the community, an effective approach, based on local source water protection programs in the U.S., would be as follows. First, the entity with legal authority to initiate source water protection efforts (in the case of Nicaragua this is probably the Mayor) would initiate a public informational meeting. During this meeting, open to everyone in the community, including all stakeholders and the general public, local government representatives would introduce the subject of source water protection and related issues. Then, attendees would have an opportunity to respond with ideas, comments, questions and concerns.

2. Formation of a Source Water Management Planning Committee

Depending on the approach of the local authority initiating the source water protection program, a small committee of individuals interested in developing a management plan would be convened either prior to, or after, a general open meeting of all stakeholders and the public. This committee is the same Source Water Management Planning Committee introduced in Chapter 5, and might be composed of stakeholders, health professionals, local water utility managers, or some combinations of these groups. The job of this committee would be to develop the source water management plan according to the process presented in Chapter 5. This work would most likely be done under the direction of the local government or local water utility. The committee would also be charged with involving stakeholders and the general public periodically in the plan development process (presented in the remainder of this chapter). Later, when the management plan is written and finalized, the Source Water Management Planning Committee could transform to an implementation committee and become responsible for review and modification of the plan on a regular schedule, for example every year or two years.

3. Obtaining Public Input

Once the Source Water Management Planning Committee is formed, one of its first actions should be to develop a schedule of events for obtaining public comment prior to and during development of the plan. Public participation via meetings is the primary mechanism to involve all stakeholders and members of the public. It is critical to clearly invite public and stakeholder comment, emphasize the openness of the process, and assure that all public and stakeholder input will be given careful consideration. Effective ways to publicize meetings and to solicit input on plan components are newspaper and radio announcements, posters, fliers, and word of mouth.

Access to the public participation process is an important element to include when planning for public input. The lead agency needs to consider how it will reach people and organizations in remote areas of the community, as well as people with mobility, hearing, or literacy challenges.

4. Presentation of the Draft Source Water Management Plan for Public Comment

The next step in public participation would be to hold a public meeting to present the draft plan to all stakeholders and the community. An explanation of what the management plan seeks to accomplish is important at this stage. Stakeholders and the general public would then review and comment upon the committee's draft proposed source water management plan. Then comments would be collected in an organized manner, often in writing or through an additional public meeting.

Public Participation in Source Water Protection in Matagalpa

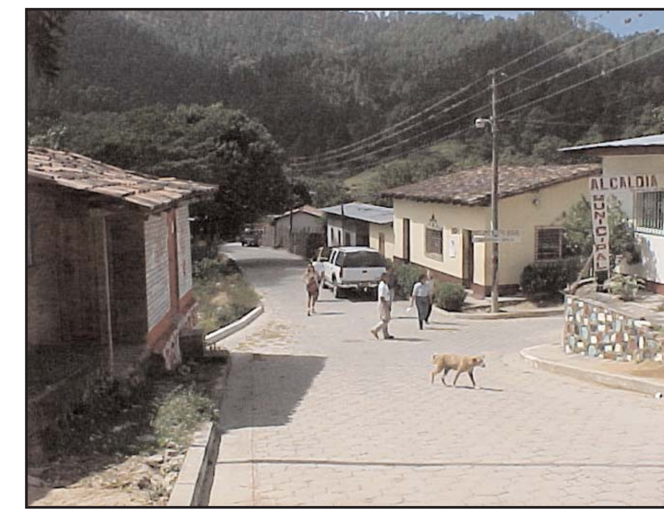
A public participation meeting was held in Matagalpa on January 18, 2001, as part of the community's pilot project. Approximately 50 stakeholders, including cattle ranchers, coffee farmers, government representatives, teachers and students, with a vital interest in the source water protection areas around Matagalpa, attended the daylong meeting. The group discussed sources of contamination affecting their drinking water and some possible management strategies to control those sources. This meeting provided an organized forum for stakeholders and members of the public to voice their own thoughts and and react to other's ideas. The outcome of the meeting was development of a list of potential contaminant sources and a list of alternatives and management strategies for the source water areas. The presence and participation of a large number of stakeholders, members of the public, and government representatives at this meeting provided strong incentive for further development of a source water management strategy for Matagalpa.

The schedule for public input should, at a minimum, include an initial meeting, a mid-project update and input meeting, and a draft-plan presentation meeting. Some communities may wish to develop a more regular schedule of meetings at which stakeholders and the public can provide input to the planning committee on a regular basis, as the source water protection plan is developed.

Figure 6.2

5. Coordination with Neighboring Communities

Coordination within a community, and between communities, can greatly increase the success of a source water management plan, and thus the protection of key water resources. The boundaries and extent of water resources, such as a river or ground water aquifer, usually do not coincide with the borders of a single community or town. Therefore, the effectiveness of actions taken in one community to protect its water source may be somewhat limited if similar actions are not taken by other communities sharing a given water source. Developing a source water management plan that is compatible with, and supportive of, the plans of other communities sharing the same water source increases the overall effectiveness of the individual community plans.



Coordination with upstream communities, such as between Ocotal and its upstream neighbor Dipilto (pictured here), can greatly increase the success of a management plan.

6. Media involvement

Involvement of the media during development of a source water management plan can assist the process of plan development in a variety of ways. In addition to helping inform stakeholders and the public and increasing public involvement, the media can play a role in encouraging community support for a source water protection program. Visibility in the media can also communicate the need for financial and technical assistance to government bodies, national and international NGOs, and lending institutions. A simple press release (such as that shown in Figure 6.3) can be used by the Source Water Management Planning Committee to inform the media during development of a management plan.

Source Water Awareness

Sample Press Release

For Immediate Release:
[Date]

Contact: [Name]
[Phone #]

Protect Your Drinking Water… Protect the Source!

[City],[State]—Have you ever thought about where your drinking water comes from, beyond the faucet? Did you know that what you do in and around your home can affect not only the quality of your water but also the quality of your neighbor's water? Find out where your drinking water really comes from and learn about how you can help protect it during a [Duration of campaign]-month-long drinking water source awareness campaign, starting [Start date], sponsored by [Name of sponsor]. The campaign will provide information on

- The source of your local drinking water
- The value of safe drinking water
- Potential threats to your local drinking water
- Steps you can take to protect your drinking water
- Contact information for additional resources on drinking water protection.

Safe drinking water is essential to a community's quality of life and continued economic growth. Yet citizens may not always be aware of safe drinking water issues in their community and may not realize what needs to be done to protect drinking water and keep it safe for their families and businesses. Drinking water wells across the country are being contaminated daily by common activities, such as pouring motor oil and household chemicals down drains, using too much pesticides and fertilizers, and littering streets with refuse that will eventually run off into rivers and streams. When water supplies are not safe, the health of the community — especially of the young, the old, and the sick — is jeopardized. In addition, communities may experience a loss of tax revenues from real estate and new jobs as businesses refuse to locate to or remain in communities with known or suspected water contamination problems.

Protecting drinking water sources is the first line of defense in ensuring safe drinking water. If communities are aware of their drinking water sources and of potential threats to these sources, they can take steps to keep the sources safe and improve their local environment. There is something everyone — from retirees to school kids to individuals in their homes — can do to help. To find out what you can do, contact [Contact name and phone number].

[Acknowledgment]

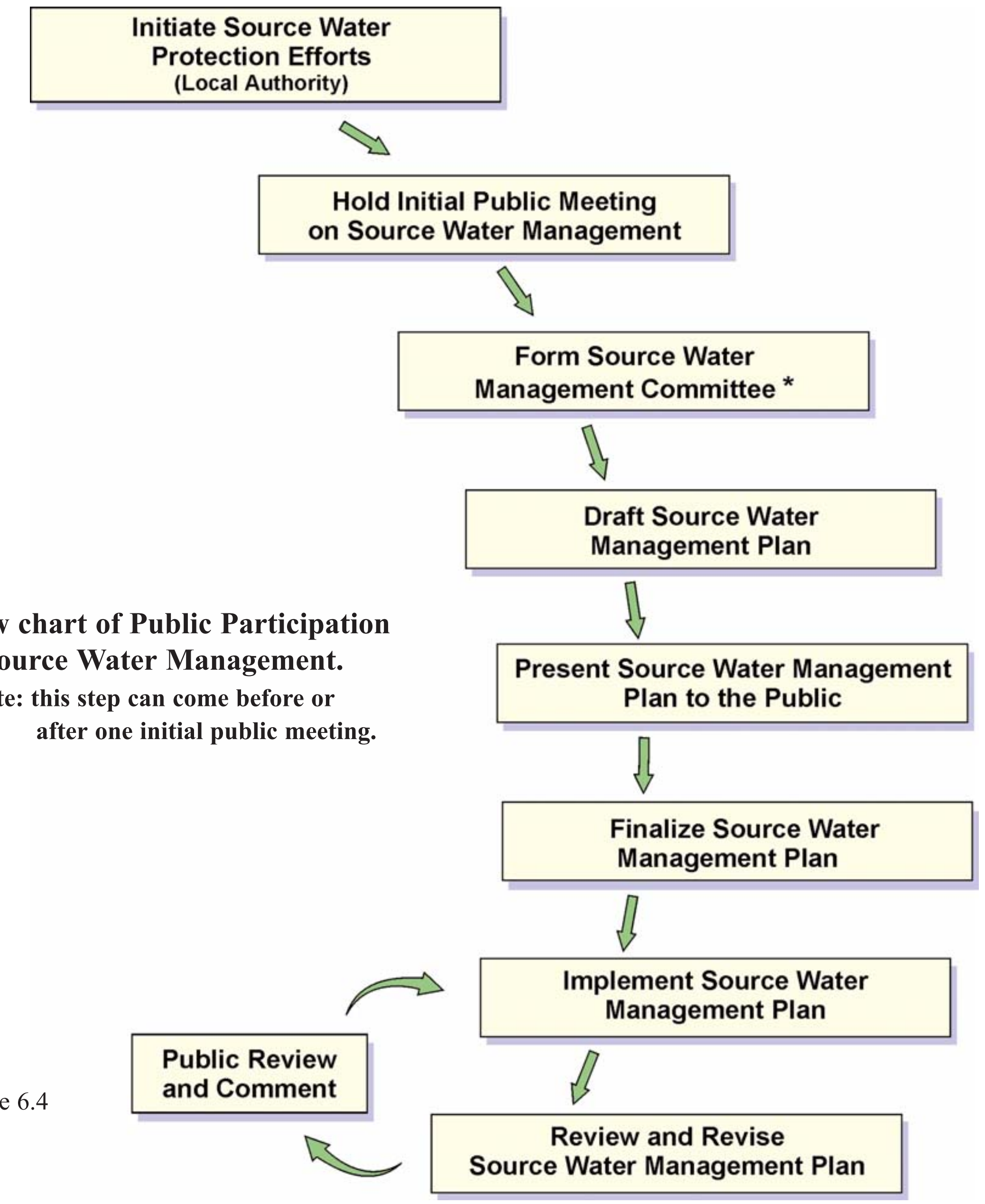
# # #

Press releases such as this one, can be used by a Source Water Management Planning committee to inform the media of a source water management planning meeting. Source: Local Government Environmental Assistance Network, 2001. Online Toolbox www.lgean.org.

Figure 6.3

7. Regular review and modification

One key to the success of a source water management plan is to maintain an open dialogue with stakeholders and the public beyond the plan development stage (presented in Chapter 5). The Source Water Management Planning Committee should institute a vehicle for regular comment or review of the management plan once it has been implemented. This can be a good source of information for the committee about how well the plan is working and what elements of the plan are effective or ineffective. In addition, a similar open dialogue should be maintained for all modifications to the plan in subsequent years after the plan is initially adopted.



Flow chart of Public Participation in Source Water Management.
*** note: this step can come before or after one initial public meeting.**

Figure 6.4

6.3 Conclusion

A source water management plan developed through public participation represents a consensus on how to best manage the drinking water sources for a community. The benefits gained from this process include awareness in the community about the issues relating to the protection of drinking water, institution of cooperative networks within the community, and commitment among stakeholders and community members to implement and uphold the management plan. The public participation process tremendously increases the potential for successful source water protection.

7 Case Studies from Pilot Projects

7.1 Overview

In an effort to develop a meaningful approach to assisting communities in Nicaragua with development of their own source water protection programs, the project began with three pilot projects in communities impacted by Hurricane Mitch. The pilot projects used different methods to address various aspects of source water management.

In Ocotal, local high school students interested in environmental issues carried out a source water protection education campaign. A committee of representatives from the mayor's office and environmental and health organizations operating in Ocotal worked together to define the target audience and create three educational brochures. The students used the brochures, as well as a survey they had created, to inform cattle ranchers, coffee farmers and seasonal coffee workers about actions they could take to protect their drinking water source.

This drawing by three local school children was used in the educational brochures distributed in Ocotal.

A significant portion of Matagalpa's drinking water comes from several watersheds surrounding the city. The local water supply agency, AYAMAT, and a local environmental education program, Proyecto Cuencas Matagalpa, organized a large public meeting to bring together stakeholders in the surrounding watersheds to discuss protection of the city's surface water sources. This meeting provided a forum for local farmers, ranchers, teachers, non-governmental organizations, students, and government representatives, and others, to voice their ideas about the threats to drinking water quality in their area and what could be done to reduce them. The stakeholders also learned about source water protection from several speakers, including AYAMAT and Proyecto Cuencas representatives, and listened to each other express their opinions as well.

Local stakeholders attend a public participation meeting on source water protection in Matagalpa.

Students in Estelí talk with workers in a furniture factory during an inventory of potential contaminant sources.

Students at Estelí's campus of the National Autonomous University of Nicaragua (UNAN) provided extensive time and effort to initiate a comprehensive source water protection endeavor in that city. The students learned how to delineate source water protection areas for each of the city's drinking water wells, and then inventoried the potential sources of contamination for each protection area.

7.2 Introduction

This chapter describes the three pilot projects that provided considerable basis for the preparation of this training, which is designed to assist Nicaraguans with development of programs to protect community drinking water sources. The purpose of the pilot projects was to provide technical assistance to the target communities while establishing approaches and methodologies for source water protection that could be applicable on a national level. The work in the pilot communities served to introduce ideas for watershed protection, test assumptions, gain reaction and input, and undertake initial actions to accomplish source water protection.

The selection of the pilot communities, Ocotal, Estelí and Matagalpa, was based on an initial assessment of conditions and opportunities for source water protection in areas damaged by Hurricane Mitch. After tentative selection, the leadership of each community was consulted to explore its interest and willingness to participate. The three towns ultimately included as part of the project represent locations of different population and geographic area, with differing source water management issues, in three distinct regions of the Mitch-affected areas of Nicaragua.

Each pilot project was designed to address a particular issue in source water management and, through empowerment to local stakeholders, to implement a specific component of source water protection:

- Estelí: delineate source water protection areas for wells;
- Ocotal: gain coordination and cooperation among various entities and communities in the watershed, and provide public education about contaminant sources;
- Matagalpa: develop effective public participation in watershed management by identifying potential sources of contamination and enumerating management solutions.

While the objective of the overall project has been to support the development of comprehensive source water protection programs in Nicaraguan communities, the pilot projects were limited to just one or two components in order to focus the work and develop meaningful products within a relatively short time frame. For each pilot project, short-term objectives were identified, approaches to meet objectives undertaken, results recorded, and future needs identified. The experience gained in the pilot towns has been integrated into this manual.

Summaries of the pilot project case studies are presented below. In addition to illustrating the unique circumstances of each community, the summaries present a concise overview of the source water protection process in Nicaragua, and how it might be expected to unfold in localities beyond the pilot project communities.

Mayor Marta Adriana Peralta was closely involved in development of the Ocotal pilot project.

7.3 Ocotal

7.3.A Objectives

- Develop partnerships among entities concerned with water quality in the community
- Develop partnerships between Ocotal and the upstream communities in the source water area
- Increase public awareness of source water issues and personal roles in protecting drinking water sources

7.3.B Project Summary

Ocotal is a town of approximately 25,000 people, located along the Río Dipilto in the Nueva Segovia Department in north-central Nicaragua. Ocotal depends on a central drinking water system that draws from an intake along the Río Dipilto just upstream of the city. The water is first treated at a central facility using filtration, sedimentation, and chlorination. While the treatment plant is one of the more advanced in Nicaragua, high loads of bacteria from storm water runoff and sediment from erosion occasionally upset the balance of the treatment process and jeopardize the quality of delivered water. Upsets to the drinking water treatment system were particularly problematic in the aftermath of Hurricane Mitch.

The permanent population of the Rio Dipilto watershed above Ocotal is 6,000 inhabitants, which swells to 24,000 during the four months of the coffee harvest. Approximately 25 percent of the permanent population within the watershed does not receive treated drinking water (IRENA, 1993). Instead, water is taken directly from the river for household use. Therefore, both the population served by the central delivery system and the population taking untreated water from the source stand to benefit from improved protection and management of source waters. This potential for improved drinking water quality provided the impetus for the source water protection pilot project in Ocotal.

The pilot project in Ocotal was initiated in July, 2000, following a meeting between EPA representatives and Mayor Marta Adriana Peralta, during which drinking water protection and its importance for the health of the community was discussed. Thanks to the enthusiastic support of the Mayor and her staff, the project got underway quickly, led by a small working group of key individuals concerned with water resources and watershed management. The working group, organized by staff in the Ocotal Alcaldía, included community associations and nongovernmental agencies, national agencies such as MAGFOR and MARENA, and international organizations working in Ocotal on issues related to water quality, watershed management, and public health.

Initially, the working group held several discussions to identify key water quality, source water protection and public health issues in the Río Dipilto watershed, and the most effective ways to begin to address them. Key questions raised in the meetings included:

- What are the most serious water quality problems affecting the health of the community?
- What are the most significant potential sources of those water quality problems?
- Who can and should be involved in remedying these problems?
- What management techniques should be considered?

Members of the Ocotal working group and EPA representatives toured the watershed.

The identified water quality issues included cattle roaming freely in the river, runoff from coffee processing flowing directly into streams, lack of use of latrines by seasonal and permanent coffee workers, and deforestation and erosion. After the working group meetings, members of the group, along with EPA representatives, toured the watershed to observe the activities relating to identified water quality concerns.

After completion of the meetings and watershed tours, the working group developed a sequence of steps to begin to address identified watershed protection needs. Targeted public education was predicted to yield the greatest impact in terms of overall watershed protection. Three of the problems identified through the meetings and field visits were selected as priorities for action, based on general consensus among the working group members. These issues were:

- contamination of the river by cattle,
- the lack of latrine use by seasonal coffee workers, and
- the absence of latrines available for use by seasonal and permanent workers in the coffee fields.

The Ocotal working group identified the need for increased use of latrines by seasonal coffee workers.

The working group identified other threats to the quality of the drinking water source, but it was agreed that these matters could be addressed later in the source water protection effort. Those additional water quality issues included improperly treated and disposed coffee wastes (husks and honey water), improperly disposed trash, and deforestation.

The Ocotal working group determined that broad public outreach on the priorities for action could be accomplished through the development and distribution of a series of educational brochures. The brochures would deliver a clear, concise source water protection message to the target groups associated with the identified priority problems: cattle ranchers, coffee farmers, and coffee pickers. In order to raise community awareness, school children were invited to design a logo for the brochures. EPA representatives developed text and graphics for separate brochures on each issue. Each brochure displayed the winning logo. Following revision and approval by the working group, 300 copies of the brochures were delivered to the Mayor's office for distribution.

The influx of seasonal coffee workers during the coffee harvest quadruples the area's population north of Ocotal.

The culmination of the educational campaign was delivery of the brochures to the target populations in the watershed. Under the leadership of COBEN (the local school of Nicaraguan biologists and eologists) a group of environmentally concerned high school students was organized into two brigades to assist with the public education effort. The students identified a set of coffee farms and cattle ranches within the watershed that they then visited once a week for 7 weeks. Small groups of students interviewed 9 coffee farm owners, 34 coffee pickers, and 11 cattle ranchers during their visits to get an idea of their environmental awareness and how that awareness increased over the course of the 7-week campaign. During each visit, students also distributed brochures and discussed water quality issues. The students used a questionnaire (a copy of one is included in this chapter) for guidance in their discussion and interviews with each audience. Responses from the people interviewed were positive, and the connection between water quality, individual action, land uses and health was conveyed successfully, according to the report compiled by the students at the conclusion of the educational campaign (a copy of the report pertaining to coffee pickers is provided in this manual).

The logo for the educational brochure used in Ocotal was developed by three school children.

7.3.C Outcomes and Accomplishments

The educational effort in Ocotal brought together a variety of stakeholders, all of who had interest in water resources and their management. The spectrum of stakeholders included businesses, residents, farmers, transient and permanent farm workers, local government, water treatment and delivery managers, non-government organizations and students ranging from elementary to high school levels. In addition, cooperation among the several communities present in the watershed (Ocotal, Dipilto, Las Manos) was initiated for the purpose of source water protection. This effort helped to open new avenues of communication and strengthen ties between the communities in working towards the common goal of drinking water protection. An increased awareness now exists on the part of the upstream communities that their actions to protect water quality can not only improve their own drinking water, but could also improve the water quality of downstream communities. An emerging sense of stewardship supports the prospect of continued progress in watershed protection for the Rio Dipilto area. It is anticipated that a regional philosophy toward source water protection will become more prevalent as communities experience the benefits of collaboration.

Informe del trabajo realizado por brigadistas ecológicos en la cuenca de el río Dipilto en la temporada de café 2000-2001.

Entrevista para los ganaderos:

Nombre de el productor ________
Nombre de la finca ________
Ubicación ________
Áreas de cultivo ________
No. de cabeza de ganado ________

I. ¿Cuántos trabajadores contrata cada a–o en su finca?

Permanente H __ M __
Temporales H __ M __

II. ¿Cómo maneja los desechos de la finca?

Casulla ________
Aguas mieles ________
Excretos ________

III. ¿Cuántas letrinas hay en su finca?

IV. ¿De qué forma orienta a los trabajadores para que usen adecuadamente las letrinas?

V. ¿De qué enfermedades padecen sus trabajadores?

En la temporada de café ________
En cualquier época ________

VI. ¿De qué forma abastece de agua a sus trabajadores?

VII. ¿De qué forma controla el ganado?

VIII. ¿De dónde toma agua el ganado?

IX. ¿Cómo utiliza los excretos y orina de el ganado?

Figure 7.1

The principal outcome of the Ocotal pilot project was a heightened awareness of water quality issues both in the community itself and in upstream areas. The community also gained first hand experience in designing and carrying out a public education campaign. As a result, students, coffee workers, coffee farmers, cattle ranchers and their families have an increased understanding of the primary health issue in their community: drinking water quality. Through the endeavors of the working group, connections have been made between workers, students, communities, local government offices, and local organizations.

7.3.D Future Endeavors

Ocotal has established a firm foundation for continued efforts in source water protection. Primary drinking water issues have been identified, practical experience in designing and implementing a public education campaign gained, and groundwork laid for the necessary cooperative efforts that will provide optimal protection of the drinking water resources in the future. A program to protect source water in Ocotal has begun in earnest, and efforts to implement a comprehensive source water protection plan, once it is developed, have a great likelihood of success.

Resultado de las Encuestas con los Cortadores de Cafe
Mayo de 2001

Preparado por: Lic. Myriam Cruz Peralta, Presidente COBEN- Ocotal y Srita. María Patricia López Aguilar, Responsable de Brigadas Ecológicas- Ocotal

En el período de realización de las encuesta se seleccionaron a dos Brigadas Ecológicas, conformada por estudiantes de secundaria de V año de el Colegio Fe y Alegría integrado por los jóvenes: Brigada " Las Golondrinas" (7 mujeres) y Brigada " Los Chacales" (8 hombres).

Estos jóvenes brigadistas se movilizaron en grupos de tres en las fincas cafetaleras de Dipilto Viejo, El Volcán y Las Manos en el municipio de Dipilto, visitaron un total de nueve fincas cafetaleras, en las cuales realizaron un total de treinta y cuatro entrevistas a cortadores de café de ellos (12 mujeres) y (22 hombres) estas personas entrevistadas año con año regresan a las mismas fincas a cortar café y lo hacen acompañados de sus hijos menores y su compañera o compañero.

Así contestaron a las preguntas los cortadores de café

I. ¿Está preocupado por la calidad de el agua que toma?

Está sucia y contaminada , sale oscura y con mal sabor, les preocupa que se puedan enfermar porque sale de la quebrada (río) , porque es necesario clorarla, por la salud de su familia, por la pulpa de el café.

II. ¿Sabe usted que cuando las personas y los animales tiran desechos al río pueden enfermarse al tomar de esta misma agua?

Sí:
No, explique por favor:

Sí, porque al tomarla ellos mismos pueden morir, porque ellos la consumen, está infestada, por las enfermedades, se contamina su organismo, perjudica la salud, el desaseo. Hay microbios que viven en los excrementos y orina, humana y animal, que no pueden ser vistos. Cuando llueve, si hay excrementos en las partes altas del río (cuenca), éstos desechos pueden caer al río llevando consigo los microbios. Si hay ganado en el río o cerca de él, éstos microbios en los desechos también caerán al río. Cuando bebe agua que contiene estos microbios invisibles puede darle fiebre, diarrea, vómitos, dolor de estómago, dolor corporal, y deshidratación. A veces estos síntomas pueden causar la muerte , especialmente, a infantes, niños y ancianos.

III. ¿ Se ha enfermado alguien en su familia recientemente, o conoce a alguien que haya estado enfermo por las causas anteriores?

Sí, la enfermedad fue causada por haber tomado agua "sucia."
No, estamos contentos que siga saludable aunque otras personas no hayan tenido la misma suerte.

Sí, se han enfermado presentando dolores de estómago. Se enfermaron los niños solamente dos, los restantes dijeron que no porque hierven o cloran el agua.

IV. Hay cosas que se pueden hacer para proteger el agua de los microbios; entre estas se destacan:

- Usar las letrinas disponibles
- Mantener las vacas fuera de el río (entre más lejos de el río mejor)
- Incluso los afluentes son importantes porque ellos suplen al río

V. ¿ Preferiría usar letrina si existieran? Si, No ¿Por qué?

Por que necesitan hacer sus necesidades, si no hay tienen que hacerlas al aire libre y luego enterrarlos, para prevenir enfermedades, para evitar la contaminación, por las moscas, para protegerse, por que es necesario tenerlas, ayuda a nuestra salud, por limpieza y seguridad, es importante para evitar los microbios.

VI. ¿Considera que debe cuidar su salud, utilizar las letrinas y cambiar algunos hábitos de higiene?

- Concienciar a los que la usan
- Para cuidar nuestra salud
- Lavarse las manos
- Clorar o hervir el agua
- Para no contaminar el agua
- Para mantener limpio
- Vivir aseados
- Lavar los alimentos
- Mantener las letrinas cerradas por las moscas
- Porque haciéndolo al aire libre podemos contraer enfermedades
- Tapar el agua
- Usar papel higiénico y quemarlo
- Limpiar o cambiar las letrinas
- No mantener animales en la cocina

VII. Brinde su opinión sobre:

- El uso de las letrinas.
- Mantener el ganado fuera de el río.

Se pude hacer esto, y si no se puede ¿Por qué no?

Puede sugerir algunas otras cosas para que esto pueda hacerse (el uso de las letrinas y alejar al ganado de el río)?

Es importante usar letrinas, se puede mantener limpia la letrina, es primordial tenerla para que nadie se enferme, donde hay agua puede haber ganado por que tienen microbios, es importante por la salud, se debe llamar la atención a personas que no mantienen limpia la letrina, porque se mantiene el agua limpia y se protege la salud, el ganado debe estar encerrado, las letrinas son muy útiles, es necesario hacer buen uso de las letrinas y mantenerlas aseadas, es una buena medida para evitar enfermedades y contaminar el agua.

VIII. ¿ Hay algunas otras acciones que puedan ser tomadas para mantener los excrementos (humanos / de animales) fuera de el alcance de el río?

- El uso de las letrinas.
- Es difícil por que mucha gente busca el campo para hacer sus necesidades; por ejemplo: en una finca de 80 trabajadores solo 3 usan letrina.
- Se debe enterrar los excretos.
- Se debe mantener tapada la letrina.
- Mantener los animales encerrados.
- No llevar el ganado al río.
- Usar los excretos como abono.
- Beber agua de pozo.
- Orientar a la población sobre el asunto de las letrinas.
- Aumentar el número de letrinas en las fincas.
- Dejarla de abono en la finca.
- Meterla en un hoyo, despulpar en seco el café, dejarle de abono.

Figure 7.2

7.4 Estelí:

7.4.A Objectives

- Delineate Source Water Protection Areas (SWPA) for Esteli wells
- Inventory potential contaminant sources for all SWPAs for all wells
- Rank potential contaminant sources in all SWPAs for wells
- Engage students, mayor’s office, and other key agencies and organizations in the city in a source water protection effort
- Develop coordination between the university and the mayor’s office

7.4.B Project Summary

The city of Estelí was chosen as a pilot project community for several reasons: the relatively large size of the community, the fact that Estelí depends on ground water sources for its drinking water, the presence of the University Center of the Northern Region of UNAN (UNAN-CURN) there, and interest on the part of the Mayor. An exploratory meeting with the Mayor took place in July, 2000, and a project to delineate the source water protection areas for wells in Estelí was launched soon thereafter.

Estelí is served by 16 drinking water wells, most of which are located in or immediately adjacent to the urban center. During initial discussions with the Mayor, concern for the longevity of these wells became evident, as did the community’s interest in developing a base of technical information about the wells and surrounding areas that would assist in the management of these drinking water sources. EPA representatives were aware of the existence of a branch of UNAN located in Estelí, and, with the support of the Mayor’s office, approached the director of the Environment and Natural Resource Management Program about student participation in a source water protection area delineation project for the drinking water wells in the city. The director of the program, Dr. Ramona Rodriguez Perez, enthusiastically supported the proposal, and worked closely with EPA representatives to formulate a credit project for third year graduate students in the environmental and natural resource management program.

The woodworking factory and tile factory, shown here, were toured by UNAN-CURN students as part of their inventory of potential sources of contamination.

The UNAN-CURN delineation project involved 25 students who participated in two EPA training sessions, one in November, 2000, and one in January, 2001. During the first class, students learned how to perform delineations of source water protection areas for wells, using the calculated fixed radius equation (based upon recharge and pumping rates) presented in Chapter 4 of this manual. After the first class, the students calculated candidate radii for all 16 wells serving the city. They then developed a map showing the circular source water protection area for each well. These calculations were based on an estimated recharge rate (assumed to be 50% of the annual precipitation rate), and 100% of the pumping capacity of each well, as suggested by the trainer for this first exercise. During the second class, EPA representatives verified the protection area calculations and provided instructions on methods to inventory potential sources of contamination within the mapped areas.

The second classroom session was immediately followed by a field trip to identify potential sources of contamination in one of the delineated areas and to collect information needed for the ranking process. The students chose a protection area for a well near the UNAN-CURN campus and walked throughout the protection area as a group with the EPA representatives. A variety of potential contaminant sources were investigated, including a woodworking shop, a tile factory, road runoff, and sewage and storm water discharge pipes from homes and businesses. Students’ knowledge of the importance of positive collaboration in the pursuit of drinking water protection goals was put into practice during discussions with owners and operators of potential contamination sources. The field trip concluded with a visit to the site of the well that currently draws water from the delineated area they had just toured, underscoring the potential impact of activities within the protection area on drinking water quality.

During the months following the second class, the students identified potential sources of contamination in each of the delineated source water protection areas. They first developed a list of potential sources of contaminants that applied specifically to the land uses and industries in their town, and then walked throughout each protection area to directly investigate all the potential contaminant sources. In the process of the investigation, the students talked with shop owners and other local people about the chemicals used, stored or disposed of at their facility, business or home. They also collected data on methods used by local shops and factories for chemical and waste storage and disposal. The students will use this information in the future when they rank the potential contaminant sources, based on potential risk and other factors, in order to develop management options. (Ranking of potential contaminant sources is discussed in more detail in Chapter 4.) This inventory exercise provided the students a clear understanding of the potential threats to the drinking water supply, and provided a basis for discussion of drinking water protection with the business owners, workers, and local agencies.

The final piece of the UNAN-CURN graduate class project will be to rank the potential sources of contamination based on a set of chosen criteria, such as travel time to the well, quantity of contaminant, or type of contaminant. (Ranking is discussed in more detail in Chapter 4.) Ranking sources will help the students to evaluate the potential risk to drinking water supplies from the sources. This information will then be shared with the municipal government to facilitate efforts to implement source water protection measures.

As the students worked on the source water area delineations, word about the project spread within

The students at UNAN-CURN delineated the source water protection area and conducted an inventory of potential contamination sources for Well #18 in Estelí, pictured here.

the community. Others began to take an interest in the project, in particular, AMCRE (Association of Municipalities of the Estelí River Watershed). Thanks to the initiative of the university, AMCRE became involved in the project. Applying its Geographic Information System (GIS) capabilities, AMCRE will work with students to digitize the maps of the source water protection areas for the Estelí wells. This effort will make the source water protection area information compatible with a variety of software applications, and thus highly useful to other institutions working in the area on natural resource management and drinking water and watershed protection.

The students also established a working relationship with the local office of ENACAL, which supplied information on well locations, pumping rates, and other design specifics. Project results will be made available to the ENACAL office to assist in operation and management decisions, and in planning for future service needs. A continued working relationship among the University, the municipality, AMCRE and ENACAL can move the source water protection effort forward into the management stages. Currently, the project is being carried ahead primarily by the work of the students at UNAN-CURN. Over time, the political leadership of the municipality and ENACAL most likely will become integral players in implementing management options. The students and professors at UNAN-CURN hope to continue working on the topic of source water protection with future classes, and to maintain the working partnerships established during this project. Continued involvement of students at the University is likely to strengthen source water protection efforts in Estelí.

7.4.C Outcomes and Accomplishments

Students in the source water protection class at UNAN-CURN each received a certificate of completion.

A number of noteworthy achievements resulted from the Estelí case study effort. The most outstanding of these was demonstration of the value of involving University students in providing technical support for drinking water protection efforts. The interest, competence, and dedication of the students and faculty involved in this project indicate that expansion of university involvement in source water protection efforts throughout Nicaragua would be a valuable component of long-term programs.

In terms of the UNAN-CURN class specifically involved in the pilot project, the students developed skills and understanding that can be put to work in the immediate future. Their determination that almost every part of the city of Estelí falls within a protection area, established an important connection for the students between land use and the potential for drinking water contamination. Other projects related to the delineation effort are being developed and collaborative efforts between the University and the local government to develop components of a source water protection program have begun.

As a result of this project, the city of Estelí now has a calculated and mapped set of candidate source water protection areas, and corresponding inventories of potential contaminant sources, for its 16 drinking water wells. The students can now use this information as a tool in pursuing the next steps in source water protection, along with the help of ENACAL, the municipality, AMCRE and other stakeholders.

Another positive outcome of the pilot project was development of a comprehensive inventory of potential contaminant sources in each source water protection area, and the ranking of potential sources of contamination within each of these areas. It is anticipated that this information will be of considerable benefit to the local government, which has indicated a strong interest in initiating a comprehensive drinking water protection program for the city.

7.4.D Future Endeavors

Professors at the University have expressed an interest in continuing to develop coursework relative to drinking water protection. This will likely be covered as part of the Physical Chemistry and Toxicology track in the Natural Resource Management Masters program (Gestión en Medio Ambiente y Recursos Naturales) at UNAN-CURN at UNAN-CURN Estelí. The students who received the training as part of the pilot project may continue with efforts to protect drinking water in Estelí or undertake similar work elsewhere. Indications from the Mayor's office are that the work of the students will contribute significantly to source water protection efforts in the community, and that this project has provided the impetus to begin to assemble a citywide strategy for drinking water protection.

The students who have participated in the pilot project in Estelí may continue with efforts to protect drinking water in Estelí or elsewhere.

The contributions of the agencies and individuals involved in the pilot project efforts in Ocotal, Estelí and Matagalpa have been invaluable in Nicaragua's effort to establish a national program to protect drinking water sources. Their assistance is greatly appreciated.

7.5 Matagalpa

7.5.A Objectives

- Public participation in source water protection
- Enhanced local management of drinking water sources
- Development of a wash basin demonstration project

7.5.B Project Summary

A community clothes washing station in Matagalpa could help prevent bacteria and harsh soaps from flowing directly into the river.

Matagalpa is a mid-sized city lying at the confluence of the Rio Molino Norte and the Rio San Francisco. Matagalpa draws its water from three major sources: the Rio Molino Norte, the Río San Francisco and the Río Aranjuez. AYAMAT is also currently investigating the possibility of drawing additional water from ground water sources in the Sébaco Valley, Chaguitillo.

The pilot project in Matagalpa built upon the activities of an existing network of local water-related groups, and focused on facilitating discussion of drinking water issues among stakeholders in the various watersheds that supply surface drinking water to Matagalpa. The source water protection areas for the combined surface and ground water drinking water sources in the Matagalpa region are vast. A local environmental education program, Proyecto Cuencas Matagalpa, has mapped these source areas for its own educational purposes, so the watershed boundaries around Matagalpa are generally recognized and understood by the community and water resource and environmental managers in the region. The effort by Proyecto Cuencas Matagalpa to delineate the watersheds and educate the community on the subject appears to have greatly facilitated source water protection efforts and management activities in and around Matagalpa.

Matagalpa is unique in that its drinking water is managed by an innovative prototype organization called AYAMAT. AYAMAT is a semi-private entity related to ENACAL working to manage protection and delivery of drinking water in a sustainable and efficient manner, with limited involvement by ENACAL. Matagalpa is also unusual in that it has a very strong, well-established environmental organization in place in the community. Proyecto Cuencas Matagalpa works with local community members and students to provide environmental education, promote environmental campaigns at the local level, and support innovative, environmentally friendly, and economically beneficial alternatives to habitual activities that contribute to the degradation of drinking water sources. The Matagalpa pilot project capitalized on the successes of these institutional arrangements to initiate a sustained public involvement program for the source water protection areas.

The first step in developing the source water protection program in Matagalpa was to work with AYAMAT and Proyecto Cuencas Matagalpa to organize a stakeholder meeting to discuss the major problems affecting drinking water quality, and to develop new ideas and options for mitigating those problems. On January 18, 2001, representatives of EPA, AYAMAT and Proyecto Cuencas Matagalpa facilitated a meeting of approximately 50 stakeholders who had been identified and invited to participate by AYAMAT and Proyecto Cuencas. Proyecto Cuencas Matagalpa was able to use its existing network from its ongoing environmental education and outreach work to identify a large group of stakeholders from throughout the surrounding watersheds. The stakeholders represented the following interests:

- Members of Proyecto Cuencas Matagalpa
- Local government officials
- Town water committees
- MARENA-Matagalpa
- National Forestry Institute (INAFOR) - Matagalpa
- Health organizations
- Small Producers Association of Molino Norte (a watershed that supplies drinking water to Matagalpa)
- Cattle ranchers
- Farmers (large- and small-scale): vegetables, grains, corn, coffee
- Tree nursery operators
- Dairy farmers
- School teachers
- Students from National Agrarian University in Managua

The first half of the day was devoted to key topics in watershed management, including:

- source water assessment and the benefits of protection;
- the role of public participation in protection of drinking water sources;
- the Proyecto Cuencas Matagalpa and current efforts underway to improve and protect source waters for Matagalpa drinking water; and
- alternative technologies and practices to address potential contamination associated with the coffee industry.

In the afternoon, EPA representatives led a discussion of the major contaminant issues in the source water areas of Matagalpa, and what might be done to mitigate the contaminants. The meeting became lively at points, with participants expressing their ideas over a spectrum of economic, political, educational and social perspectives. While significant differences of opinion emerged over the course of the meeting, many vital issues were put forth for discussion. Ultimately, the group identified nine significant sources of contamination:

- Honey waters from coffee processing
- Trash – plastics, wrappers, glass
- Cattle ranching
- Clothes washing directly in the rivers
- Dairy farming
- Leather processing
- Pesticides and chemicals used in high volumes on flower farms
- Sewage waste
- Deforestation (effects on quality and quantity of water)

The discussion clearly bolstered the process of source water protection. Several of the participants made a point to say that the meeting was well worth the time spent and they were glad to have participated. Others felt the community needed to have more meetings of a similar nature to discuss issues and initiate action. In general, the group concluded that more education on drinking water quality and protection was needed in the watershed communities.

One of the major themes emerging from the public meeting was the need for and interest in alternative technologies to reduce negative impacts on water quality and watershed ecosystems. Alternatives discussed included the following:

- Use of coffee pulp as an organic fertilizer;
- Use of biogas instead of wood;
- Reduced use of water in coffee processing;
- Treatment of honey water;
- Use of the inner coffee husk to form energy bricks

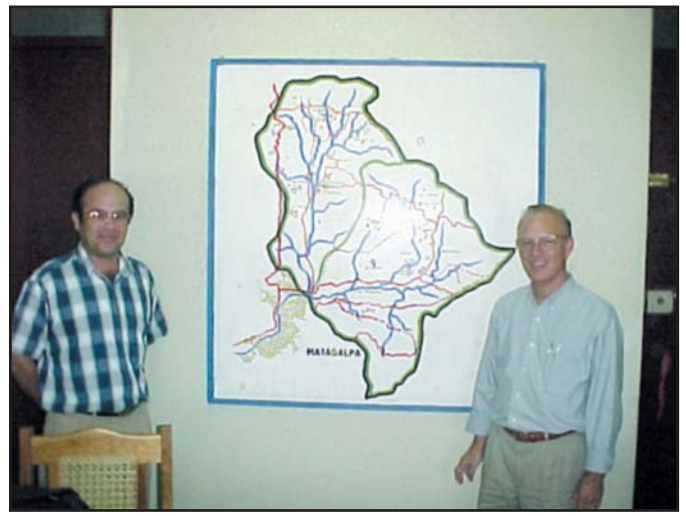
to reduce wood consumption;
- Use of more efficient ovens; and
- Use of community clothes-washing stations located away from the river.

Participants in the public participation meeting in Matagalpa tour the coffee waste treatment technologies at Selva Negra.

7.5.C Outcomes and Accomplishments

Based on the feedback of participants, the Matagalpa public meeting was clearly effective in raising the level of awareness of watershed issues, and in generating interest to resolve them. Some of the more notable successes were the large number of participants, the broad representation of diverse interests from a large geographical area, and the considerable interchange that took place among the presenters and audience. Such interaction is a critical element of the source water protection process. The presence of several government representatives at the meeting, from international, national and local levels, gave people a sense that their ideas and comments mattered, and further added to the momentum generated by the meeting. In the future, further discussion of issues surrounding source water protection and management can be hosted through the outreach network of Proyecto Cuencas Matagalpa.

The Matagalpa public meeting was also an opportunity to showcase one of the leading examples of local source water management in Nicaragua. It was evident from the discussions over the course of the day that AYAMAT is in a unique position to react to the issues brought up at the meeting and to work with the watershed communities to continue the effort of source water protection. As more people become aware of the existence and operation of entities like AYAMAT, local communities may be stimulated to apply the model to their own situations and, in the process, bring source water protection efforts closer to home.



Leaders from Proyecto Cuencas Matagalpa and AYAMAT use this watershed map (above) and 3-dimensional model (below) to point out potential contamination sources and drinking water intake locations.

7.5.D Future Endeavors

The Matagalpa public meeting laid the foundation for a highly participatory public involvement process in the creation of a source water protection plan for the region. EPA representatives promoted the idea of further meetings as a means of keeping attention focused on water quality issues and generating action.

During the public meeting, one of the issues raised was the impact of clothes washing on river water quality. From this discussion emerged the idea of constructing a community wash station set back from the river and supplied by water diverted from the river. The wash water could be directed to an infiltration area to prevent discharge directly to the river. This wash station, which could accommodate a small number of families, could be used as a demonstration project for other similar projects in the future. Such a facility could serve as a model and encourage broad scale use as a means to protect surface water quality.

8 Innovative and Alternative Technologies

8.1 Introduction

We are continually increasing our own awareness about the negative impacts of human activity on environmental resources. For example, the use of rivers to discharge industrial and municipal wastewater, the application of agrochemicals to crops, and the practice of burying hazardous wastes have been recognized as major causes of environmental damage and, in some cases, human health problems. In response, communities and societies around the globe have begun to undertake efforts to adapt activities and to develop innovative practices that better protect resources and ecosystems.

In particular, many effective innovative and alternative technologies have been developed to address water pollution problems both at the community and the individual level. Conventional practices, such as disposing of coffee husks and honey waters from coffee processing directly into a surface water body, washing clothes directly in a river, and allowing cattle to roam directly into a river to drink, sometimes have associated environmental costs like pollution of water resources. Innovative and alternative technologies are ways of meeting community needs such that negative environmental impacts are reduced or eliminated.

Some innovative and alternative technologies are now being applied in communities in Nicaragua that are working to reduce contamination in the watersheds, achieve cleaner drinking water, improve environmental health, realize cost savings, and limit the overuse of resources.

The benefits to drinking water quality from the use of innovative and alternative technologies can be significant. Therefore, a chapter of this manual is devoted to summarizing several of these. As drinking water resource management plans are developed in the communities of Nicaragua, it is important to consider how and where innovative and alternative technologies can be employed. Whether taken as a direct application of the alternatives presented here, an adaptation of them, or a formulation of altogether new approaches, innovative technologies can significantly increase the success and/or reduce the cost of a drinking water protection program both at a national and local level. Water resource managers and other leaders should pursue opportunities for developing new and alternative technologies.

It should be noted that three of the innovative and alternative technologies presented in this chapter could result in pollution of groundwater. The benefits gained from clothes washing stations, cattle watering troughs away from surface waters, and latrines all rely on the process of filtration for contaminant removal. The percolated water can eventually reach the ground water, with the slight possibility of carrying with it nutrients, viruses and bacteria from cattle waste, human waste and clothes washing water. These technologies could potentially cause pollution of groundwater resources. While these technologies may not be ideal in terms of protection of water supplies, they do provide a marked improvement over direct discharge to surface waters that serve as sources of drinking water.

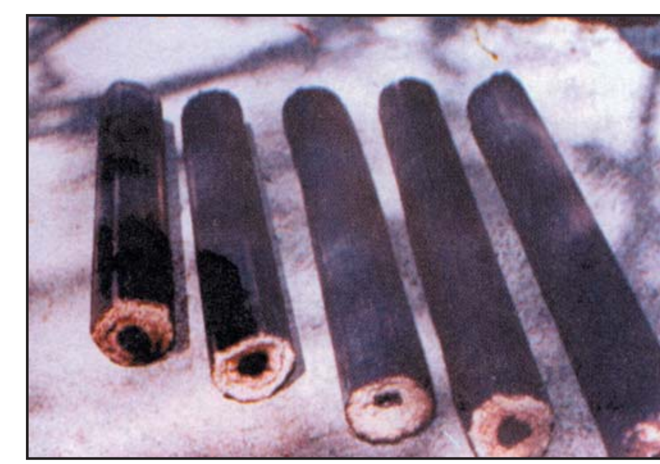
Finally, it is also important to note that in Nicaragua, personal property taxes or improvement taxes may be imposed on certain types of new construction. This fact may act as a deterrent to individuals who might otherwise employ an alternative technology. A significant initial investment, sometimes required to institute a technology, might also be a disincentive for implementation. An effort to eliminate such disincentives could include working with the local municipality to develop a program of tax breaks or other incentives as part of the source water protection and management plan (see Chapter 6 for further discussion).

Firewood collection contributes to unstable conditions on hillsides leaving them vulnerable to erosion.

8.2 Innovative and Alternative Technologies Applicable in Nicaragua

1) Fuel bricks from coffee husks (cascarillas)

According to Proyecto Cuencas Matagalpa, a watershed protection program in Matagalpa, fuel bricks (briquetas) can produce more energy than a similarly sized log of firewood. Several neighborhoods in the north of Matagalpa have begun using briquetas for fuel (Proyecto Cuencas Matagalpa, 2000) instead of wood. The coffee husk bricks can replace some of the need for firewood, which is already sparse on many hillsides due to previous deforestation. Further cutting of trees for firewood promotes unstable conditions on hillsides, and leaves the terrain vulnerable to erosion. Erosion of soils from the hillsides can cause heavy sedimentation in rivers and streams, which can impact the quality of drinking water sources. Using coffee husks for fuel bricks or purchasing fuel bricks instead of firewood can slow the rate of deforestation on hillsides. The recycling of coffee husks in this manner also reduces the practice of discharging husks directly into surface waters, which is a typical means of disposal during the coffee harvest season.



Fuel bricks produce more energy than a similarily sized log of firewood.

2) Composting of coffee husks (pulpa de café) for fertilizer

Coffee husks can also be composted (allowed to decompose in a pile) and used for fertilizer the next year. Coffee husk composting requires construction of a sump or basin, usually built of cement or brick, in which the coffee husks can settle out of the honey waters. The honey waters are diverted elsewhere for further treatment and the coffee husks are moved to a compost area. A separate area near the settling basin must be designated where the husks can be composted. This area can be a simple hand-dug hole in the ground or just an open space for a compost pile. It is estimated that recycling husks from a coffee farm can provide fertilizer for approximately 20 percent of that farm (Kuhl, 2001), potentially cutting fertilizer costs by 20 percent. Cost savings on fertilizer can therefore cover the initial construction cost for the settling basin rather quickly. Coffee husk composting can be instituted on a farm of any size.

Coffee husks can be collected, composted, and turned into fertilizer.

3) Biogas production from biodigestion of honey waters in coffee production

Honey waters produced in wet coffee processing (lavado del café) are extremely high in organic material (such as sugars). When this material is broken down by naturally occurring bacteria, methane gas is produced. This process is called biodigestion, and can be carried out in a biodigester tank (see photo at right). The methane is captured within the tank and delivered to homes via simple pipe systems for use in cooking. Use of biogas as a fuel is usually only efficient when it can be produced near the area where it is used. The gas can be used as a cooking fuel in place of wood.

Proyecto Cuencas Matagalpa has been working with area coffee farms to construct and implement the use of biodigesters to produce biogas. At least four farms have begun to use the biogas they are producing in their biodigesters (Proyecto Cuencas Matagalpa, 2000).

Biogas produced from the decomposition of coffee husks can be collected and used as a fuel source.

4) Clothes washing station

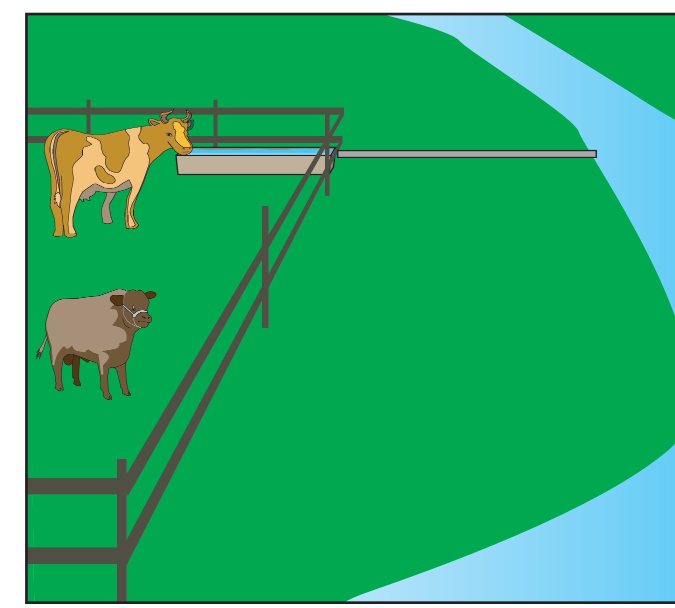
Washing clothes in a river can contribute significant amounts of bacteria and soaps to the river. By washing clothes away from rivers, the pollution load from soiled clothes and soap can be minimized or eliminated. Clothes washing stations for small communities or neighborhoods can be constructed in convenient locations away from rivers. Typically, a pipe is constructed and water is transported via gravity or pumped from the river to a cement wash station at least 100 meters from the edge of the river. The discharge water from the wash station is directed to a specified location to infiltrate into the ground before it returns to the river. Infiltration allows bacteria to be filtered out of the water by the soil, and absorption or uptake of the nutrients in soap to take place. Any water returning to the river via underground flow has lower levels of pollutants. Ready-made washbasins, as well as piping, fittings, and valves can be purchased in most large towns.

Washing clothes away from rivers prevents bacteria and soap from entering a surface drinking water source.

A community may wish to form a small management board to take care of maintenance and management of a community wash station. Money is usually required for upkeep of the system, or for power for a water pump, if one is used. Possible sources of funds include the local government, water utilities, non-governmental organizations working in the area, and user fees. Each community must determine the best method to support the day to day operation and maintenance of a wash station.

5) Watering troughs

Keeping cattle or other livestock out of rivers and streams is essential to protecting surface water quality. Excrement and urine from livestock can be a major source of drinking water pollution. One method to restrain livestock is to fence off surface water bodies and provide animals with an alternative source of drinking water. A trough of water located well away from a river or stream can be supplied with water from upstream via a gravity pipe or by pumping it up from the river if necessary. While construction of troughs and fences may require a significant initial investment, and maintenance needs can be high, the benefits to water quality from reduced bacteria and nitrogen entering a surface drinking water supply can be considerable. Similar to wash basin projects, sources of funds might include local governments, water utilities, non-governmental organizations working in the area, and user fees.



Water troughs must be provided for livestock restrained from rivers and streams by use of fencing.

6) Public/community latrines

One of the sources of bacterial inputs to rivers and streams is overland runoff of human waste. In an effort to reduce open defecation in unvegetated areas, especially roadsides, communities could invest in public latrines in critical locations. Such locations might include bus stops, coffee pick-up stations, markets, and other sites where people typically gather for periods of time. Public latrines would need to be sited and built in a manner protective of water supplies. They should be located away from rivers and streams and should be designed to ensure that wastes are filtered into the ground rather than carried off in any storm runoff to a surface water body.

Public latrines in gathering places like local markets can reduce the need for open defecation.

7) Sand filters

Sand filters can be used for cleansing relatively small volumes of surface water or spring water for individual dwellings and small communities at higher elevations where bacterial contaminants are less likely to occur in high concentrations. Ideally, sand filters would be used as one step in a series of water treatment steps that would also include disinfection, such as chlorination. However, even in the absence of possible further treatment options, filtration of drinking water is a worthwhile practice. Because of the relatively limited capacity of sand filters to reduce contamination levels in water, they are only practical in areas where bacterial and other contaminant inputs are relatively low. Typically, the least contaminated surface waters occur close to the water sources in the upper watersheds. An example of a region that could benefit from increased use of sand filters is the higher elevations in the Río Dipilto watershed.

Sand filters can be effective in filtering out some particulate matter, such as suspended sediments and particulate metals from water. Basic sand filtration can also remove some bacteria that may be attached to particulate matter in the water. Water is diverted from a stream or river and dispersed at a slow rate of flow through a container of sand, collected at the bottom of the container, and piped by gravity flow to the home or homes using the supply. Sand filters of varying sizes can be constructed depending on the volume and flow of water to be cleaned on a daily basis. It is very important to size the sand filter appropriately for the volume and flow of water being treated in order to allow for the maximum contaminant removal. An improperly sized or maintained sand filter could be virtually ineffective, or could harbor growth of bacteria or build-up of contaminants within the sand bed. The sand should be clean and should be replaced frequently, depending on the level of bacterial contamination of the water. Finally, the top of the sand filter should be covered, while still maintaining plenty of open air circulation for the sand and water, in order to prevent contamination from animals.

9 Sources of Information

One of the most important pieces in the source water protection process is accessing the available body of information about the source water area of interest. There is no need to start from scratch when information may already exist about: land uses in the watershed, water quality, topography, water distribution, current management, and other relevant topics. In addition, experiences from source water protection efforts in other areas can be helpful in planning a local effort. Below is a list of possible sources of information in local communities and in the greater national and international community that may be of help. A majority of this contact information was gathered from web sites hosted by the organizations listed below, and is as current as the information provided on the web site. All web site locations and contact information otherwise collected are current as of May, 2001.

9.1 Nicaraguan Local and National Government Organizations

Local Alcaldía
Planning and land use information
Statistics about population, land uses, local programs

Empresa Nicaraguense de Acueductos y Alcantarillados (ENACAL)
Km 5 ½ Carretera Sur
Contiguo a la Casona E.E.U.U.
Managua, Nicaragua
Tel: 505-265-0861
Fax: 505-265-0981

Local offices may also be able to provide:
Well Information
Water Service and Distribution Information

Acueductos y Alcantarillados de Matagalpa (AYAMAT)
Contiguo a Interbank
Matagalpa, Nicaragua
Tel: 505-6125461, 6122979
Fax: 505-6123148

Instituto Nicaraguense de Estudios Territoriales (INETER)
Direccion de Recursos Naturales
Frente a la Policlinica Oriental del Seguro Social
Apdo. Postal 2110
Managua, Nicaragua
Tel: 505-249-2756
Fax: 505-249-1890
Topographic maps
Map of major watersheds in Nicaragua
Map of average annual precipitation in Nicaragua
Map of average high precipitation in post El-Nino years in Nicaragua
Hydrogeologic Maps and Cross-sections

Ministerio Agropecuario y Forestal (MAGFOR)
www.magfor.gob.ni (Spanish)

Agricultural and forestry resources
Soil information
Land use information
Planning and land use information
Statistics about population, land use programs

Ministerio de Salud (MINSA)
Complejo Nacional de Salud "Dra. Concepción Palacios"
Costado Oeste Colonia Primero de Mayo
Managua, Nicaragua
Tel: 505-289-7274, 289-7235
www.minsa.gob.ni (Spanish)

Public health information
Water quality information in some water treatment plants

Ministerio del Ambiente y Recursos Naturales (MARENA)
Dirección General del Ambiente y Recursos Hídricos (DGA)
Km 12 ½, Carretera Norte
Apartado Postal 5123
Managua, Nicaragua
Tel: 505-263-2095/ 263-2088
Fax: 505-263-2088/ 263-2354

Asociacion Municipios de la Cuenca y Subcuencas Tributarias del Río Estelí (AMCRE)
Esteli, Nueva Segovia, Nicaragua
Tel: 505-713-7725
Fax: 505-713-6721
amcre@ibw.com.ni

9.2 Foreign Government and Multilateral Organizations

US Environmental Protection Agency
Office of Water Home Page
www.epa.gov/OW/index.html (English)
Office of Ground Water and Drinking Water Home Page
www.epa.gov/safewater (English)
El agua potable y la salud: lo que Ud. debe saber
www.epa.gov/safewater/agua/apsalud.html (Spanish)
Estándares de Agua Potable en Los Estados Unidos
www.epa.gov/safewater/agua/estandares.html (Spanish)
Drinking water contaminants – Fact Sheets
www.epa.gov/safewater/hfacts.html (English)

Safe Drinking Water Help Line:
www.epa.gov/OGWDW/drinklink.html (English and Spanish)
Tel: 800-426-4791 (toll free from the US)

US Peace Corps

Colonia Bolonia
Canal 2, 1c. Abajo, 2 cuadra al sur
Managua, Nicaragua
Tel: 505-266-7033/ 266-7034/ 266-7035/ 266-7036
Fax: 505-266-1392

US Agency for International Development (USAID)

Nicaragua Mission
De la Loteria Nacional, 200 metros abajo
Frente a Syscom
Pista Sub-Urbana, Apartado Postal C-167, zp-13
Managua, Nicaragua
Tel: 505-267-0502
Fax: 505-278-3828
www.usaid.org.ni (English)

USAID Environmental Health Project

Del Hotel Colón 1c. al sur, 1 ½ arriba, Los Robles
Managua, Nicaragua
Tel: 505-270-2380, 505-270-2517
Fax: 505-278-4961
www.ehpnicaragua.org.ni (Spanish)

The World Bank

De los Semaforos de la Centroamerica
400 mts. Abajos, segundo piso Edificio SYSCOM
Managua, Nicaragua
Tel: 505-270-000
Fax: 505-270-0077
www.worldbank.org (English)

United Nations Development Program

Rotonda El Gueguense
Plaza Espana 400 mts al sur
Apartado Postal 3260
Managua, Nicaragua
Tel: 505-266-3191, 505-266-3193, 505-266-3195
505-266-1701, 505-266-3155
Fax: 505-266-6909
www.undp.org.ni (Spanish)

The World Health Organization

Home Page
www.who.int/home-page/index.es.shtml (Spanish)
Links to Environment and Health related information
http://www.who.int/home/map_ht.html#Environment and Lifestyle (English)
Drinking water quality information and contaminant guidelines
http://www.who.int/water_sanitation_health/Water_quality/drinkwat.htm (English)
http://www.cepis.ops-oms.org/indexeng.html (Spanish)

Pan American Health Organization

Oficina Sanitaria Panamericana
Complejo Nacional de Salud
Apartado Postal 1309
Managua, Nicaragua
Tel: 505-289-4200, 505-289-4800
Fax: 505-289-4999
www.ops.org.ni (Spanish)

Information about health, links to technical documents and references about diseases and disease prevention, databases, and contact information

Comite Coordinador Regional de Instituciones de Agua Potable y Saneamiento de Centroamerica, Panama y Republica Dominicana (CAPRE)

Avenidas Central y Primera, Calle 5
Edificio la Llanuca, Piso 15
Apdo. Postal 5120-1000
San Jose, Costa Rica
Tel: 506-222-4392/ 257-6054
Fax: 506-222-3941

9.3 Non-Governmental Organizations

CARE International

Sandy's Carretera a Masaya
1c. abajo, ½ c. al lago
Apartado Postal 3084
Managua, Nicaragua
Tel: 505-267-8395, 505-278-3834, 505-278-0018, 505-278-0115
Fax: 505-267-0386

CARE International supports rural water, sanitation and preventive health projects in communities in Nicaragua. These projects include PALESA, the El Viejo Potable Water project, the Latrines and Health Education Project, and the Water for Today and Tomorrow project. For more information, visit www.care.org.ni. (Spanish)

Amigos de las Americas

Amigos de las Américas, a Non-governmental organization from the United States, brings volunteer teams to work with small communities on sanitation, environmental education, and drinking water projects, as well as on other community development issues.
In Nicaragua, AMIGOS' partner organization is CARE International (see above).

Auxilio Mundial – World Relief

Managua, Nicaragua
Tel: 505-265-3415, 505-265-3430

Agua Para la Vida

2311 Webster Street
Berkeley, CA 94705, USA
Tel: 510-643-8003, 510-528-8318
Fax: 510-643-5571

Agua Para la Vida is a non-profit organization started in 1987 to help start small rural Nicaraguan communities to construct their own drinking water systems.

9.4 Educational and Research Institutions

Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)

7170 CATIE
Apdo. Postal 19-7170
Turrialba, Costa Rica
Tel: 506-556-6081, ext. 337
Fax: 506-556-6166

Proyecto Cuencas Matagalpa

Edificio Alcaldía de Matagalpa
Planta Alta
Matagalpa, Nicaragua
Tel: 505-612-2850
cuencama@ibw.ni.com

Environmental education project to protect the watersheds around Matagalpa

Universidad Nacional Autonoma de Nicaragua (UNAN)

UNAN - Managua
ENEL Central 3 Km al Sur
Apartado Postal: 663
Managua, Nicaragua
Tel: 505-278-6769
Fax: 505-277-4943
www.unan.edu.ni (Spanish)

Universidad Nacional Autonoma de Nicaragua (UNAN)

Centro Universitario Region Norte (CURN)
Programa de Gestion en Medio Ambiente y Recursos Naturales
Estelí, Nicaragua
Tel: 505-713-2437, 505-713-6890

Universidad Centroamericana de Managua (UCA)

Pista de la Resistencia, semáforos de ENEL 500mts. al este
Apartado Postal #69
Managua, Nicaragua
Tel: 505-2783923
Fax: 505-2670106
www.uca.edu.ni (Spanish)

Universidad Nacional de Ingenieria (UNI)

Campus "Simón Bólivar"
Avenida Universitaria, Managua, Nicaragua
Campus "Pedro Arauz P.," Costado Sur Villa Progreso
Managua, Nicaragua
Apartado Postal 5595
Tel: 505-267-0274, 505-249-4287
Fax: 505-267-3709
www.uni.edu.ni (Spanish)

Universidad Nacional Agraria (UNA)

Km 12 1/2, Carretera Norte
Apartado postal No. 453, Managua
tel: 505-2331619
fax: 505-2331950
www.una.edu.ni (Spanish)

Escuela Agricola Panamericana Zamorano

www.zamorano.edu.hn (Spanish and English)

Latin American Network Information Center

www.lanic.utexas.edu (English)

Links to helpful websites in Latin America, by region or country, under the topics of sustainable development, economics, government, media, social sciences and more.

Centro Panamericano de Ingenieria Sanitaria y Ciencas del Ambiente (CEPIS)

http://www.cepis.ops-oms.org (Spanish and English)

Virtual library of information about health, water quality and sanitation in Latin America.

9.5 Documents from the Pilot Project Arena That May Be Useful

Estelí

- "Estelí Municipal Development Plan" (in Spanish).
- Basic Information for the Implementation of a Plan for the Rehabilitation, Management and Conservation of Watersheds that are Used for Potable Water Supply in the Departments of Estelí, Madriz and Nueva Segovia." ENACAL, Northern Technical Assistance Unit.
- Environmental Rehabilitation Plan – Southern Río Estelí Watershed. Preliminary Version. National Service of Watershed Management (SENOC), MARENA, the Interinstitutional Commission for the Recuperation and Conservation of the Río Estelí Watershed (CICRE), and German Social Technical Cooperation Service (DED).
- Water Quality Data for Drinking Water Wells in Estelí, Complete Physical Chemical Analysis Performed in Regional Laboratory, Urban Sector, Municipality of Estelí. 1999. ENACAL – Estelí.
- Estelí Water Supply Plan showing locations of public water supply wells.

Ocotal

- Municipal Governments of Dipilto and Ocotal, Nueva Segovia. Process of Improvement of Citizen Participation for Sustainable Development. Intermunicipal Forum of Dipilto, Ecological Situation of the Río Dipilto. August 19, 1997.
- Project Document: A Green Ocotal to the 21st Century. Municipal Government of Ocotal and Community. Forest Management and Reforestation in Ocotal Region.
- Map of Barrios in Ocotal.
- 1999 Population projection (urban and rural) in Ocotal, by age group and sex.

Matagalpa

- Proyecto Cuencas Matagalpa. Bulletin. 2000. Matagalpa, Nicaragua.
- Proyecto Cuencas Matagalpa. Environmental Education Modules. 2000. Matagalpa, Nicaragua.
- Potential Land Use within Two Major Drinking Water Watersheds in Matagalpa
- Actual Versus Potential Land Use within Two Major Drinking Water Watersheds in Matagalpa
- Soils within Two Major Drinking Water Watersheds in Matagalpa
- Potential Evapotranspiration within Two Major Drinking Water Watersheds in Matagalpa
- Proposed Forestry and Forest Protection within Two Major Drinking Water Watersheds in Matagalpa
- Changes in Land Use for Annual Cultivation and Coffee within Two Major Drinking Water Watersheds in Matagalpa
- Hydrologic Conditions within Two Major Drinking Water Watersheds in Matagalpa

General

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Glossary of Terms

Aquifer: A subsurface unit of rock or sediment characterized by formations and/or sediments capable of storing and transmitting water in sufficient quantities to supply pumping wells.

Biodigestion: Bacterial breakdown of organic material, such as that found in discharge waters from coffee processing, that produces methane as a byproduct.

Compost: A mixture of decaying organic matter used to improve soils and provide nutrients.

Conservation Easement: A legal mechanism under which a private landowner relinquishes land use rights to a town, national government, individual or conservation group in exchange for some financial benefit to the land owner.

Ground Water: Water beneath the earth's surface.

Pesticide: Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating pests including weeds, insects and fungus.

PH test: A measurement of a substance to show whether it is acidic or basic based on the concentration of hydrogen ions present.

Recharge: Water, typically from precipitation, that seeps into the ground and reaches a ground water aquifer.

Runoff: Precipitation that does not seep into the ground, but flows down slope over the land surface to the nearest surface water body.

Source Water Protection Area (SWPA): An area that supplies water to a public water supply, ground water well, or surface water intake.

Stakeholders: Any individuals or groups, such as local farmers, trade organizations, government entities, local businesses, and community residents with an interest in the quality of drinking water and management of source water areas.

Surface Water: Water occurring at the land surface, including streams, rivers, ponds, lakes, estuaries and the ocean.

Uniform Flow Equation: A mathematical equation that can be solved to delineate the down-gradient and lateral limits of a source water protection area for a well.

Volumetric Flow Equation: Equation that can be used in the Calculated Fixed Radius method to delineate a source water protection area for a well.

Watershed: The land area that contributes water to the mouth of a river or stream, or to a lake.
Watershed Area: The land area from which water drains to a point on a receiving body of water.

Zone of Contribution: The land area through which recharge occurs and beneath which water flows to a pumping well.

Glossary of Acronyms

AMCRE: Association of Municipalities of the Estelí River Watershed (Asociación de Municipios de la Cuenca del Rio Estelí)

AYAMAT: Aqueducts and Sewerage of Matagalpa (Acueductos y Alcantarillados de Matagalpa)

CFR: Calculated Fixed Radius method, used to delineate a source water protection area for a well. The basic equation used is $r = (Q/Rp)1/2$, where r = radius of the protection area (feet), Q = well pumping rate (cubic feet/year) and R = recharge rate (feet/year).

COBEN: High School of Biologists and Ecologists of Nicaragua (Colegio de Biologistas y Ecologistas de Nicaragua)

CURN: UNAN University Center of the Northern Region (Centro Universitario de la Region Norte)

ENACAL: Nicaraguan Aqueduct and Sewer Company (Empresa Nicaraguense de Acueductos y Alcantarillados)

ENACAL-DAR: Rural Areas Division of the Nicaraguan Aqueduct and Sewer Company (Empresa Nicaraguense de Acueductos y Alcantarillados – División de Areas Rurales)

EPA: United States Environmental Protection Agency

GIS: Geographic Information System

INAFOR: National Forestry Institute (Instituto Nacional Forestal)

INETER: Nicaraguan Institute of Territorial Studies (Instituto Nicaraguense de Estudios Territoriales)

MAGFOR: Ministry of Agriculture and Forestry (Ministerio de Agricultura y Forestal)

MARENA: Ministry of Environment and Natural Resources (Ministerio de Ambiente y Recursos Naturales)

MINSA: Ministry of Health (Ministerio de Salud)

PAHO: Pan American Health Organization

UNAN: National Autonomous University of Nicaragua (Universidad Nacional Autonoma de Nicaragua)

USAID: United States Agency for International Development

USDA: United States Department of Agriculture

WHO: World Health Organization