TP# 28: 06/85

UNDERSTANDING WATER SUPPLY: GENERAL CONSIDERATIONS

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PREFACE

This paper is one of a series published by Volunteers in Technical Assistance to provide an introduction to specific state-of-the-art technologies of interest to people in developing countries. The papers are intended to be used as guidelines to help people choose technologies that are suitable to their situations. They are not intended to provide construction or implementation details. People are urged to contact VITA or a similar organization for further information and technical assistance if they find that a particular technology seems to meet their needs.

The papers in the series were written, reviewed, and illustrated almost entirely by VITA Volunteer technical experts on a purely voluntary basis. Some 500 volunteers were involved in the production of the first 100 titles issued, contributing approximately 5,000 hours of their time. VITA staff included Maria Giannuzzi as editor, Julie Berman handling typesetting and layout, and Margaret Crouch as project manager.

The author of this paper, VITA Volunteer Joe Remmers, is a civil engineer who designs and constructs water and wastewater facilities for Black & Veatch Construction Engineers. He has prepared plans and specifications for various construction projects in Saudi Arabia. The reviewers are also VITA Volunteers. Dr. F.O. Blackwell is an associate professor in environmental health with the East Carolina University School of Allied Health. He has worked as a health and sanitation adviser with the United States Agency for International Development in Pakistan, and has taught at the American University of Beirut, Lebanon School of Public Health. Morton S. Hilbert, P.E., is chairman and professor in the department of environmental and industrial health at the University of Michigan School of Public Health. He is a registered professional engineer and has worked in the field of environmental health in 20 countries in Africa, South America, Central America, and Asia.

VITA is a private, nonprofit organization that supports people working on technical problems in developing countries. VITA offers information and assistance aimed at helping individuals and groups to select and implement technologies appropriate to their situations. VITA maintains an International Inquiry Service, a specialized documentation center, and a computerized roster of volunteer technical consultants; manages long-term field projects; and publishes a variety of technical manuals and papers. For more information about VITA services in general, or the technology presented in this paper, contact VITA at 1815 North Lynn Street, Suite 200, Arlington, Virginia 22209 USA.

UNDERSTANDING WATER SUPPLY--GENERAL CONSIDERATIONS

by VITA Volunteer Joe Remmers

I. INTRODUCTION

Water supply systems have been a vital part of human life since before recorded history. Early "systems" consisted of no more than simply drawing water out of a river or lake with a jar or bowl. Later, aqueducts were built to move water to more desirable locations. Such was the case in ancient Egyptian societies. The Romans were known to have developed aqueducts for conveying water for use within their cities. Cast iron piping was reportedly used in Europe in the seventeenth century. Hand pumps appeared for the first time toward the latter half of the eighteenth century. Water system technology changed drastically during the Industrial Revolution when engine- and motor-driven pumps were developed. Chlorine was discovered to be an effective germ-killing agent and modern pipe manufacturing techniques were invented. Today, water systems around the world provide safe drinking water for millions of people.

In those parts of the world not served by water systems, however, inadequate water supplies continue to be a major problem. The World Health Organization has estimated that approximately 1,100 million people do not have access to safe and adequate water supplies. In response to this urgent need for improved water supply and sanitation, the United Nations declared the 1980s to be the International Drinking Water and Sanitation Decade. The goal is to provide safe water in sufficient quantity for all the world's people by 1990.

Improved water systems can help to provide adequate supplies of safe drinking water in these regions. "Safe" water is water that does not contain disease-producing organisms (e.g., cholera, typhoid fever, dysentery, worms) and does not contain harmful chemicals (e.g., arsenic, lead). The reasons for developing a water supply system are simple: to transport water from its source; to treat it so that it is safe to drink; to distribute it to wherever it is needed; and to store it whenever necessary for future use.

A properly designed and constructed water system, which is operated and maintained correctly, will provide a safe and adequate water supply for the people of the district the system supports. In addition to furnishing safe drinking water for a community, a water supply system can provide irrigation water and water for industrial purposes. A safe, adequate, and economical source of water for agricultural and industrial uses could stimulate the economic growth and overall well-being of a particular region.

The purpose of this paper is to provide basic information and data for those individuals responsible for developing a safe, economical, and practical water system for their communities. It examines the various factors that must be considered before development of a water system is started. More detailed information can be found in the other papers within VITA's "Understanding Water Supply" series. These other papers cover the following topics:

Water Supply--Sources
Water Supply--Treatment
Water Supply--Storage
Water Supply--Distribution

This paper is not intended to serve as a design manual; for particular design problems, the services of specially trained persons should be sought.

II. COSTS AND BENEFITS OF WATER SYSTEMS

The construction and operation of a water supply system can be costly, so the benefits of constructing such a system must be properly assessed. Usually, the benefits far outweigh the costs. Having a readily available source of water provides economic benefits because people who formerly needed to carry water for long periods every day will be free to attend to other matters such as farming, trade, or business. The most important benefit of a safe and adequate water supply is the prevention of waterborne diseases that are present where water is not good.

The most expensive items in a water supply system would be heavy equipment such as pumps, motors, and treatment equipment. Next would be buildings and tanks. Depending on the size of the system and type of piping material used, the least expensive component would be the distribution piping.

The cost of labor must also be considered. Community members may wish to do the job themselves to avoid having to hire outside help. But this approach may have a hidden cost if it distracts people from their primary job, farming for example, and causes productivity to go down. But community projects are working well in many areas, and the inherent pride of ownership may offset other costs.

III. SYSTEM DESCRIPTION

CHARACTERISTICS

Water systems consist of the following basic components: (1) a water source, such as a lake, stream, spring, river, or underground aquifer; (2) a method of transportation from the source to the user, such as a canal system or pump/pipe system; (3) a method of treatment, such as sedimentation, filtration, or disinfection; and (4) a method of storage, such as a closed tank, standpipe, or a protected reservoir. A system does not necessarily need all of the above components. Required components would depend on the particular needs of the community served.

RESOURCES

The resources required for the development of a water system depend on the complexity of the system. In general, a system should be kept as simple as possible to minimize the strain on available resources. The resources required to develop a water supply system are discussed below.

Materials

Materials that are needed for building a water system may include concrete for storage tanks and treatment facilities; steel, cast iron, copper, and plastic (among other materials) for piping; and other construction materials, such as wood, brick, mortar and clay, to build units to house treatment and pumping facilities. Hypochlorite or chlorine gas will be needed for disinfection of a newly-constructed system. In the event of the threat of disease, a continuing supply of these chemicals should be available to disinfect the daily water supply.

Labor

A substantial amount of hand labor is required to construct a water system. The number of laborers depends on the availability of equipment--the more heavy machinery available the less need for manual laborers. Labor would be needed to construct dams or canals, to dig trenches about .3 to 1 meter deep, to carry and lay pipe, and to construct treatment facilities, pump houses, and tanks. Most of the required labor could be unskilled, but some semi-skilled or skilled workers would also be needed. Pipe laying techniques can be learned rather quickly, but construction of buildings and tanks is more complex and must be learned over a period of time. If an area contains very few skilled individuals, a training program may have to be established before undertaking construction projects.

Equipment

Equipment as simple as a shovel or as complicated as power-operated heavy machinery (such as a backhoe) can be used. A community should use what is available and affordable to them. For instance, when only shovels are available, the project would be labor-intensive, and probably less costly. It would also probably take longer. If backhoes, bulldozers, or trenchers are available and affordable, the project would be equipment-intensive. It would probably also be more costly, but would likely be finished more quickly than a labor-intensive system.

To construct treatment works, pump houses, and tanks, concrete mixers, wheelbarrows, scaffolds, and assorted hand tools would be helpful. Tanks and facilities constructed of steel would require more complex equipment such as welding kits, cranes, and precision measuring instruments.

Components of the system include equipment such as pumps, engines, motors, valves, gauges, screens, filters, flocculators, sludge collectors, and chlorinators. Again, not all this equipment would necessarily appear in one system--the amount depends on the system's level of complexity.

Energy

Energy is needed to run any water system. Energy is required to pump water up from aquifers, to move it from the treatment plant to storage tanks at higher elevations, and to send it through the distribution system. This energy can come from gravity--water flowing downhill--or it can come from human resources--applying mechanical motion to a hand pump. Energy can also be derived from the wind, the sun, fossil fuels, or from the water itself, as with a hydraulic ram or water wheel. If electric generating plants are in the area, this source of energy should be investigated. Energy is costly, so the most economical and reliable source should be considered.

Design

Before any effort is made to develop a water system, the services of competent design professionals should be sought. These professionals are typically civil or mechanical engineers, or other water resource specialists. Contractors who are in the water line construction business, as well as plumbers and pipefitters, could also be of assistance. Design professionals can help with sizing a water system, determining water pressures, determining the right treatment methods to use, designing structures, and estimating construction and operating costs.

Testing

To ensure that a water supply is safe for drinking, some method of periodic testing should be provided for. If the water supply is suspected as the source of a disease outbreak, additional bacteriological testing is required. Laboratories that can check water for both bacteriological and chemical safety are generally operated by government health agencies. Field kits and equipment for bacteriological testing are also available and local persons can be trained to use them. In the event a laboratory is not available, these kits should be used for testing water supplies.

Special Circumstances

The community owning a water supply system must have contingency plans in case certain events occur. Such an event might be the outbreak of a waterborne disease. Or, the water source could dry up, as in the event of a drought. Contingency plans should include alternate sources of water or an emergency tank or reservoir.

MAINTENANCE REQUIREMENTS

Water pipes or mains, when properly installed, do not often require maintenance. Occasionally, a line may break, requiring a crew to go out and repair it. Valves require some maintenance. They should be operated periodically to avoid the build-up of mineral deposits.

The greatest maintenance requirements are found at the pumping and/or treatment works. Any time there are moving parts, mechanical breakdowns will occur and experienced mechanics will be needed to fix them. Filters at the treatment works will need periodic cleaning, as will any settling basins. Routine checks and inspections as well as data collection and recording (pumping records, electricity used, chemicals used, etc.) must be carried out.

Laboratory tests for bacteria (coliform) must be done at regular intervals (daily, weekly, or monthly, depending on the number of persons served). Chemical testing needs to be done only yearly unless problems are suspected.

Maintenance is an ongoing expense. It must be considered in the early cost/benefit analysis and provided for as resources are allocated. Some communities cover maintenance costs through a system of user fees.

IV. DESIGNING THE SYSTEM RIGHT FOR YOU

DESIGN CONSIDERATIONS

The first consideration in designing a water supply system is to determine the total quantity of water the system would be required to deliver. Water quantities are usually based on the number of persons a community's system is required to serve. A commonly accepted water demand factor used in practice today is 550 liters per person per day, a figure that allows for some commercial and laundry use. In areas where survival is threatened by water shortages, a smaller amount per person should be considered so that water can be provided to more people. Under extreme conditions, the minimum allotment should be 90 liters per person per day.

The figure per person should then be multiplied by the total population of the community to arrive at the average daily demand (ADD). The peak flow, defined as the consumption during the time of heaviest use, should be used to determine the volume of storage required and the pipe sizes needed in the system. The peak flow can be estimated by multiplying the ADD by 2.5.

The second consideration in designing a water system is to determine the pressure requirements at various points in the system. The pressure requirements affect energy costs, and, therefore, a good portion of operating costs. Calculating the pressures in the system also gives an indication of the type and size of pumps that may be required. A piped system should, ideally, be under positive pressure at all times to minimize any infiltration of contaminated water, and thus prevent disease.

SCALE

Water systems can be constructed to serve large regions such as entire countries or cities; they can serve small communities; or they can serve only a single family residence. In some cases, a centralized system having only a few sources of supply and distributing water areawide may be preferable to many small systems serving individual communities or residences. Because its main waterworks can be monitored more easily, the centralized system has lower operating costs and better control over the safety of the water. In other cases, smaller systems may be a better choice. The choice of either a centralized plant or smaller systems should be determined by the users' needs and resources. If energy supplies are limited and hand pumps are the only pumps available, a system using hand pumps should be considered rather than one requiring motor- or engine-driven pumps. The availability of trained, qualified persons to operate and maintain the system properly must also be assessed.

Water systems should be constructed as simply as possible. Gravity storage tanks supplied by a single-speed pump are favored over variable-speed pumps feeding a water network. Treatment units, such as settling basins, can be cleaned manually rather than with automatic scrapers and sludge pumping systems. Provision for disinfecting the water should be made when there is the possibility of contamination. Water taps can be centrally located, or the water can be piped to each individual home. Transport distances must be considered carefully because of costs and other technical questions.

A major factor in determining the size of a water system is the consumers' ability to pay for the water service. If sufficient revenues can be generated, the water district can become self-supporting. This should be the ideal goal.

USE OF LOCAL RESOURCES

A list should be compiled to see what manufacturers and suppliers are available in a given area as a source for pipes, supplies, pumps, valves, and replacement parts. Also, an investigation should be made to see what raw materials might be available. Such an investigation should include searches for the right clays to make brick, minerals for cement, and sand and rock for concrete. Available manpower should be assessed to see who would be qualified to work on a water project. An inventory of equipment such as backhoes, cranes, trenchers, and bulldozers should also be made to determine availability.

PUBLIC EDUCATION

An aggressive public education campaign may be necessary to ensure the acceptance and proper use of a water supply system by consumers. If people have never had safe water, they may not at first appreciate its value and use it in a manner that will preserve the system and conserve the water.

Long-term use and maintenance of the system will require the support of the users. If the users of the system are involved in its planning, construction, operation, and maintenance, the acceptance and use of the supply will be much greater than in situations where the system is installed without local participation. The involvement of local residents in the development of four new community water supply systems in Honduras is described in the October 1982 and January 1985 issues of VITA News (see Bibliography). The success of these water systems is due in large part to the efforts of community members.

POSSIBLE PROBLEMS TO CONSIDER

The more complex a system is, the more likely it will have water line breaks or maintenance problems. The design phase of a water system should contemplate the simplest system possible that meets the needs of the community. Acquiring the necessary raw materials might also be a major problem. If materials are not readily available and must be brought in from long distances, the development costs will be increased. Sources of safe drinking water are not always obvious to the community. Locating sources, such as underground aquifers, can be time consuming and costly. In many parts of the world, a water supply system is totally foreign to the residents. Personnel would have to be trained in constructing, operating, maintaining, and administering the system. As stated earlier, the public may also need to be made aware of the importance of safe water and of their role in using and preserving the system.

The potential problems outlined above and any others must be carefully studied and resolved before development of a water supply system is started to ensure the success of the system.

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Water Supply-General Considerations
ISBN #0-86619-231-X