

**SALVE REGINA UNIVERSITY**

**HUMAN FACTORS FOSTERING SUSTAINABLE SAFE DRINKING WATER**

**A DISSERTATION SUBMITTED TO  
THE FACULTY OF THE HUMANITIES PROGRAM  
IN CANDIDACY FOR THE DEGREE OF  
DOCTOR OF PHILOSOPHY**

**BY**

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PREVIEW

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PREVIEW

## ABSTRACT

This dissertation, *Human Factors Fostering Sustainable Safe Drinking Water*, examines from a humanities perspective, scientific and cultural data to assess the relationship and impact of drinking water challenges on the human condition in eight different communities: Mystic, CT, New London, CT, Bar Harbor, ME, South Portland, ME, Orleans, MA, Falmouth, MA, Jamestown, RI, and Newport, RI. Specifically measured is the technological and cultural response to the problem of limited drinking water resources by examining the water management and the art, ethics, history, literature, philosophy, and religious practices of each community.

A non-traditional approach to qualitative research through a review of direct observations and collection of data was employed in order to measure the communities' practices and extrapolate the attitudes and values that might influence people's perception and use of their drinking water resources. This unique approach combining the humanities and science has enabled a rich analysis of my research question, "Which human factors influence some New England communities to effectively manage their resources so as to maintain a sustainable drinking water supply?"

This study also incorporates scientific data from local, county, state, and federal agencies, as well as private organizations, which were obtained through local water reports, environmental assessments, the United States Geologic Survey (USGS), EPA publications, and websites. Data was primarily derived from the years 2000-2005. For example the majority of the demographic data was extrapolated from the year 2000 census.

Information and data about the eight communities were collected from a review of literature and direct field observations. First the eight communities were evaluated according to their drinking water's level of sustainability during 2001 to 2003. Then the demographic, economic, and human factors were coded based on the influence they might have towards the community achieving sustainable water supplies. Analyses and categorization of this information in order to assess each community's water supplies and water usage practices entailed assembling tables, drawing flow charts, and discussing findings.

The study concludes that the smallest populated communities, Bar Harbor and Orleans were evaluated as sustainable and the largest populated communities, Falmouth and Newport were evaluated as unsustainable. The individual variables and groupings of these variables did not reveal any other consistent relationships. However, each of the communities studied exhibited some environmental awareness toward their community's water supply. Their awareness may be a positive indication that they will be able to succeed in sustaining future water reserves.

## ACKNOWLEDGEMENTS

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### *The Peace Prayer of Saint Francis*

O Lord, make me an instrument of Thy Peace!  
Where there is hatred, let me sow love.  
Where there is injury, pardon.  
Where there is discord, harmony.  
Where there is doubt, faith.  
Where there is despair, hope.  
Where there is darkness, light.  
Where there is sorrow, joy.

Oh Divine Master, grant that I may not  
so much seek to be consoled as to console;  
to be understood as to understand;  
to be loved as to love;  
for it is in giving that we receive;  
it is in pardoning that we are pardoned;  
and it is in dying that we are born to Eternal Life.

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## ABBREVIATIONS, ACRONYMS AND DEFINITIONS

B = Bubblers = drinking water dispenser  
C = cups  
CBSM = community-based social marketing  
Cl<sub>2</sub> = chlorine  
CT DEP = Connecticut Department of Environmental Protection  
DEP = Department of Environmental Protection  
E = coffee  
EPA = USEPA = United States Environmental Protection Agency  
Fountain = ornamental water structure  
GAC = granular activated carbon  
GIS = geographic information system  
gpm = g/min = gallon/minute  
H<sub>2</sub>O = pure water  
HCF = hundred cubic feet  
I = ≤ 1 liter bottled water  
K = kitchen  
MCL = maximum contamination limit  
MGD = million gallons per day  
M.I.T = Massachusetts Institute of Technology  
NA = not applicable  
NRDC = National Resource Defense Council  
O<sub>3</sub> = ozone  
P = present  
RIDH = Rhode Island Department of Health  
S# = Significant observation refer to page of appendix  
SDW = Safe Drinking Water  
SDWA = Safe Drinking Water Act  
SRU = Salve Regina University  
TCE = trichloroethylene  
TOC = total organic carbon  
US = United States  
USEPA = EPA = United States Environmental Protection Agency  
USGS = United States Geological Survey  
UV = ultraviolet  
V = vending  
∅ = No significant water related observation recorded  
0 = absent  
+ = improves water efficiency  
∅ = neutral water efficiency  
- = decreases water efficiency  
5g = 5 gallon dispenser

## CHAPTER 1

### INTRODUCTION

**Water, like religion and ideology, has the power to move millions of people. Since the very birth of human civilization, people have moved to settle close to it. People move when there is too little of it. People move when there is too much of it. People journey down it. People write, sing and dance about it. People fight over it. And all people, everywhere and every day, need it.**

**Mikhail Gorbachev, President of GreenCross International (Swanson 2001, 7)**

This study explores the relationship between humans and their environment. In particular, it examines the relationship between people and their drinking water resources through observations and data collections from eight representative communities. The dissertation attempts to identify practices that communities could adopt in order to achieve and maintain a sustainable drinking water supply. Specifically, it seeks to identify which human factors some New England communities already have established to effectively manage their resources so as to provide a sustainable supply of safe drinking water.

The question here is: "Which human factors influence some New England communities to effectively manage their resources so as to maintain a sustainable drinking water supply?" To answer this question both technology and the humanities will be examined. The humanities can provide a helpful rationale and structure for this investigation because art, ethics, history, literature, philosophy, and religion reflect human viewpoints. While purely technological approaches neglect human considerations, the humanities often downplay technological issues. Each community was studied in terms of informational data and human cultural attitudes and practices.

In this introduction the rationale as to the validity of the research question is defined, justified, and defended. Then background information is provided regarding the natural history of water and human civilizations' evolution related to water. This is followed by some technical details that discuss safe drinking water and assess the current status of drinking water. The chapter then states how the humanities relate to the technological aspect of this research. In the concluding section, the entire dissertation's organization is detailed.

### **Thesis**

There are identifiable factors that influence a community's success in maintaining a sustainable drinking supply that would assist other communities' sustainable resource management. The variables that foster a community's effective water management are cultural and technological. These factors should first lead a community to recognize a potable water supply as a precious asset and to practice steps necessary to sustain this asset. To determine how cultural and technological factors help promote this effort, eight coastal New England towns were examined from 2004 to 2005. It is proposed that an investigation into attitudes, beliefs, and behaviors is needed to establish positive sustainable strategies. A basic motivation is required for the distribution of essential resources such as safe drinking water to all. Humanity needs to take measures to insure adequate safe drinking water supplies for all people and not just a select few. These factors could assist other communities in sustainable resource management.

Approximately half of the world's population, primarily in the developing countries, now faces a water crisis (Miller 2001, 325). However, the other half of the

world's population does not. There is little motivation for those who are not directly impacted by the water crisis to manage their water resources without economic or regulatory incentives. The United States' strong centralized political management structure imparts the impression that there is a federal government regulatory agency overseeing our nation's water supply as well as the bottled water industry. However, increasing numbers of Americans are using personal water purification systems or bottled water for reasons of convenience, preference, conformity, or health. It is the health aspect that this study will focus on.

### **Relationship of Thesis to the Doctoral Program**

Salve Regina University (SRU) offers a unique Ph.D. program that allows graduate students to expand their specialty field by first building an extensive foundation in the humanities with a conceptual emphasis on what it means to be human in today's technological world. Although the study of non-point source pollution in Newport Harbor was undertaken as this researcher's Master's thesis, it merely served as a base for the dissertation. The humanities' approach enables the expansion of the knowledge base for an investigation into how humans can improve their quality of life in regards to the water supply. This research includes art and recreation, law and ethics, historical insights, writings (both literary and informational) and public records that reflect philosophical or religious views on individual rights versus community responsibilities. For purposes of this research, eight representative communities were chosen to model these mechanisms and influences. A multi-faceted approach calling for religion, social structures, and science to aid in this change is considered. The 2000 Presidential



candidate, Al Gore, called for individuals to take more responsibility for the health of our planet. He asserted, “Perhaps most important, we each need to assess our own relationship to the natural world and renew, at the deepest level of personal integrity, a connection to it. And that can only happen if we renew what is authentic and true in every aspect of our lives” (Gore 1992, 366).

Some disciplines, such as anthropology, have proposed strategies for evaluating the human condition and shaping the future. Peter R. Gould’s *Man Against His Environment: A Game Theoretic Framework* (1963) states that man has become the primary shaper of our earth’s surface. He also believes that “Unfortunately, we have all too often lacked, or failed to consider, conceptual frameworks of theory in which to examine Man’s relationship to his environment, the manner in which he weighs the alternatives presented, and the rationality of his choices once they have been made” (Vayda, ed. 1969, 234). About twenty-five years later, Jared Diamond published a popular book, *Collapse: How Societies Choose to Fail or Succeed* (2005) that traces the responses of several societies to challenges that ultimately led to their success or failure. Diamond uses an anthropological framework similar to that recommended by Gould. In *Human Ecology: Following Nature’s Lead* (2002), Frederick Steiner supports the notion that humans actively shape their physical world. Furthermore, he notes that some environmentalists claim to have successfully slowed down anthropocentric degradation (Steiner 2002, xi). Steiner proposes that integrating many disciplines, studying previous events, and applying available technologies will enable humans to improve their living conditions. He also points out that many important cultural innovations were the result of

catastrophes, such as the construction of New York's sewer system in response to water-borne diseases (Ibid., 102).

The field of psychology offers important insight into the motivation of individuals. Specifically *Ecopsychology: Restoring the Earth Healing the Mind* (1995) provides a collection of essays, primarily by psychologists, that puts forward a theory of man's emotional relationship to the environment. Traditionally, there have been two contrasting views. One version of the Christian ethic sees the world and nature as existing to serve humankind. The extreme view that God created the world to be exploited by man may be linked with "fear of religious doubt" (Roszak, Gomes, and Kanner 1995, 247). In contrast, the environmental ethic also embraced by some Christian theologians sees man as a steward of the planet, responsible for conducting his affairs for the long-term stability of all living organisms and their interactions with their environment. In the extreme, Gaia followers see the world as self-regulating but not necessarily supporting man's negative behaviors. Ecopsychology integrates these two views by proposing that man serves his own interests best when he seeks to live in greater harmony with the natural world. More precisely, "our consumption habits are connected to deep addictive attractions" (Ibid., xvi). At the same time, man can choose to live with nature's dynamic processes to proceed, unfettered, in his eternal quest for equilibrium.

### **Importance of This Dissertation's Focus**

The United Nations reports that twenty percent of the global human population does not have access to adequate water supplies (Miller 2001, 325). These figures are supported by numerous other publications, such as *Water* (de Villiers 2000) and *Water*

*Wars: Drought, Flood, Folly, and the Politics of Thirst* (Ward 2002). *Water Quality and Availability: A Reference Handbook* (Miller and Miller 1992), library searches, and web searches referenced thousands of articles and books related to the general issue. The quantity and quality of local, national, and international water supplies is examined in the literature review. The literary research indicates a global water crisis. The deteriorating quality and dwindling supply of safe drinking water adversely affects health, the economy, and the environment and may lead to declines in the standard of living and quality of life.

Unfortunately, many individuals and groups do not manage their drinking water supplies responsibly and even squander water for nonessential purposes. Some municipalities waste it with poor infrastructure maintenance while other groups wield it as a political tool (Ward 2002, 178-186). Safe drinking water is essential to life, and technology has liberated humanity from the need to settle only where potable surface water is available. Today, a community in the desert or on an island can draw its drinking water from a distant river or lake, and customers need pay only a utility bill to a supplier. No longer burdened with the daily chore of hauling water from a communal well, today's typical urban dweller simply turns the handle of a faucet to receive safe water. The success of technology, which has disconnected people from the source of their water, causes them to take it for granted.

Once behaviors and attitudes are analyzed, this knowledge will help to develop a strategy for sustainable management of drinking water resources. This study seeks to identify the factors that influence practices and policies so as to recommend changes that might have a broad and beneficial application beyond the eight communities studied.

Effective solutions need to be found, as indicated in the *2002 EPA New England State of the Environment Report*. It established a priority for raising public awareness about the importance of safe drinking water (EPA 2002, 12). This complex problem must be understood fully and addressed comprehensively. This dissertation attempts to be a piece in the problem solving process.

The problem is very complex because there are times when humans have too much water and times when they have too little. Over thousands of years humans have developed technologies to attain a water balance. Water is an essential human need that is generally taken for granted, especially in the United States, but the perception of declining quantity and quality of drinking water has become a United Nations world concern as well as a popular culture eco-disaster theme. However, a few texts, like *The Skeptical Environmentalist: Measuring the Real State of the World* (Lomborg 2002) and *Hard Green: Saving the Environment from the Environmentalists* (Huber 1999), disputed some of the environmentalists' positions. Different authors present selectively chosen facts and figures in tables and graphs to illustrate differing scenarios.

The question remains, will society marshal its vast technological resources to secure safe and accessible water supplies, or will the water problem limit our society as it has harmed past civilizations? Historically, water has been a renewable resource, but now it has become a non-renewable resource in some areas. Out of the current world population of about 6 billion people, some 1.4 billion people lack access to clean drinking water and two-thirds of the world's households do not even have running water (Miller 2001, 298).

The availability of adequate and safe public drinking water supplies is currently of local, state, federal, and international concern. The United Nations Secretary-General called for a “blue revolution” in his millennium address (Annan 2000, 21). Technology is available to improve the safety of public water supplies. Individuals and their communities need to embrace these technologies, in order to increase their own and fellow citizens’ access to safe public drinking water.

From an international perspective, the United Nations, the World Health Organization, and the World Bank warn that the world’s supply of drinking water is both deteriorating and diminishing. Globally, since the demand for water is doubling every twenty-one years, “conflicts over water rights and resources are inevitable” (Moore 1999, 9-6 [*sic*]). Paul Simon, a popular singer and song writer, has used his popularity to advocate for the protection of water resources. In the preface for *Whose Water is It?* he writes his concern:

I fear for the future of water—and humanity—if people continue on the course that has been set: using water at a rate faster than it can be replenished, wasting water, making multiple claims on the same reservoir, failing to consider the consequences of overuse on the environment and future supply of this invaluable resource, and failing to move ahead on finding less expensive ways of converting salt water to fresh water and on construction of desalination plants. (McDonald and Jehl 2003, vii)

If supplies of safe drinking water are declining, we may infer that technologies such as improvements in water management are either not happening or are not happening fast enough. By management improvements we mean ways of managing water more efficiently. We want to reduce wasted water by using less water to accomplish the same benefit or outcome. Water must be directed to those uses which provide the greatest returns to society. Alternatives to the use of water in industrial processes, and reduction

of contamination to improve the quality of drinking water supplies must be explored and found.

It is not enough that adequate supplies of safe drinking water exist, the water must also be accessible to those who need it. Issues of economics, legal and moral rights, and means of allocation and distribution must be addressed. Understanding the challenge will help us to facilitate the adoption of these improvements. People need to better understand how market forces, regulatory processes, popular opinion, and private practices interact and translate into overall drinking water management. We also need to understand the attitudes, beliefs, and behaviors of the individuals who drive the markets, vote for our elected officials, and make the billions of day-to-day choices. These cumulatively tip the balance between sustainability and depletion of the water supply. It is critical that people understand what influences cultural norms and practices. It is at this level that advocacy for sustainable management of safe drinking water either succeeds or fails.

Our technologically developed country is tantalized with images of squeaky-clean people wearing freshly laundered clothing, sliding behind the wheel of a glistening automobile in front of a home with a lush, green lawn. A thirty-minute shower in a modern stall delivers more than 300 gallons of water, yet the typical home's septic system is designed to handle only 250 gallons per bedroom per day (Hammer and Hammer 1996, 408). The consumer is rarely told that massive, unsustainable quantities of water are necessary to maintain this coveted lifestyle. To a large degree, consumerism causes us to value these symbols of affluence without considering their costs in terms of sustainability. Fortunately, the conservation message is reaching the masses. For

example on July 5, 2005, a Metro DC bus poster by [www.usewaterwisely.com](http://www.usewaterwisely.com) indicated that by turning the water on and off when you brush your teeth you could save three gallons per day or 1000 gallons per year.

### **Water's Planetary Role**

Certain unique properties of water enable the Earth to sustain life. Scientists are now looking for signs of life away from Earth with international explorations of outer space trying to discover water on other planets. If water is traced to an area, that area may have supported or may still support life forms. Humans and all other life forms have probably depended on water since the beginning of time. The activities of certain agricultural societies are programmed around the monsoon cycles. Animals have evolved migratory routes that follow the rain. Plants have evolved physical structures to capture water effectively from their habitat. Bacteria can form an inactive cyst when water is not available, yet become active as soon as water is present again. Our drinking water has been around for billions of years and circulated through other animals, lakes, glaciers, and septic systems (<http://elibrary.bigchalk.com> accessed 3/7/06).

The primary reason that water supports life is its chemical structure. The water molecule,  $H_2O$ , is composed of two hydrogen atoms sharing their electrons with an oxygen atom. Weak bonds called hydrogen bonds form between the oxygen and hydrogen atoms of adjacent water molecules. These hydrogen bonds account for water's ability to be a universal solvent and demonstrate high heat capacity, efficient cooling capacity, capillary action, and volumetric expansion at its freezing point. Pure water, water with only  $H_2O$ , is neither acidic nor alkaline, with a neutral pH value of 7. Most



tap water, surface water, bottled water, precipitation, and groundwater have additional atoms such as calcium, sodium, potassium, magnesium, and iron dissolved in it. These atoms may change the pH as with acid rain, which has a pH of less than 5.0 (Miller 2001, 242). The more acidic or basic the water, the more likely it contains atoms other than hydrogen and oxygen.

Figure 1.1. The Water Cycle (<http://ga.water.usgs.gov/edu/watercycle.html> accessed on 3/24/06)

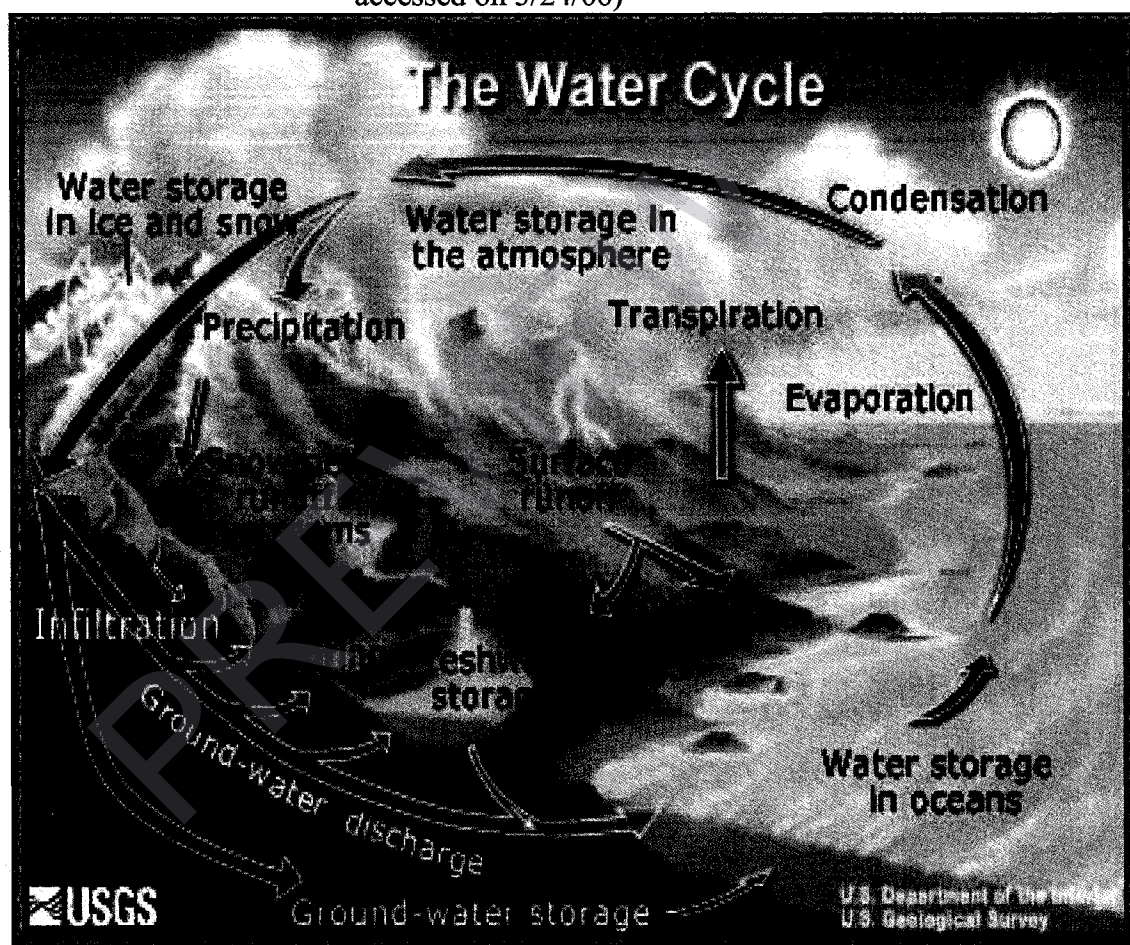


Illustration by John M. Evans, Colorado District, USGS

The earth's fixed water supply is collected, purified, and distributed during the hydrologic cycle, also referred to as the water cycle (See Figure 1.1). The cycle includes precipitation, transpiration, condensation, evaporation, infiltration, percolation, and