CHANGING THE WAY WE LOOK AT WATER: A SOFT PATH APPROACH TO GROUNDWATER MANAGEMENT IN SAN ANTONIO, TX

by

Brooke J. Bollwahn, B.A.

A thesis submitted to the Graduate Council of
Texas State University in partial fulfillment
of the requirements for the degree of
Master of Science
with a Major in Sustainability Studies
December 2017

Committee Members:

Vicente Lopes, Chair

Hyun Yun

Audrey McKinney

DEDICATION

Always first, I offer my deepest gratitude to my parents and my family. The love and support I have been showered with for my entire life is the greatest gift anyone could ever receive.

ACKNOWLEDGEMENTS

I would like to thank Dr. Lopes for serving as my advisor and mentor. I would not have made it this far without his assistance, and I am truly grateful. Thank you to Dr. Yun, without whom the quantitative portion of this paper would not have been possible. Your willingness to help and your assistance in analyzing my data are greatly appreciated. I would also like to thank Dr. McKinney, whose thoughtful questions never fail to introduce a new perspective. You have demonstrated alternative ways to look at problems/information/life, and I have no doubt this perspective will continue to impact my life and interactions as I move forward.

I would like to extend my gratitude to the water management institutions who were kind enough to participate in my survey. Thank you to my individual contacts, and to the employees of the San Antonio River Authority, the Texas Water Development Board, and the San Antonio Water System who participated in my survey. Your participation enabled a crucial portion of this paper to be completed, and I am grateful for your assistance.

Finally, I would like to thank Eddie Miles III, who has made my life away from family bearable, and my boss Dr. John Bernal for allowing me the flexibility to pursue my degree.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

ABSTRACT

Water stress and water scarcity are significant problems across the globe, and rising populations will see increasing demand for water as well. Traditional supply and demand management strategies have had some success, but projections based on these strategies still predict a water deficit in the coming years in cities such as San Antonio, TX. The soft path paradigm offers an alternative water management strategy with the potential to greatly reduce or eliminate San Antonio's projected water deficit. This study discusses the barriers and opportunities involved in implementing a soft path approach to groundwater management in San Antonio. Implementation of a new paradigm will depend in large part on the local and state water management institutions charged with managing San Antonio's water resources. Employees of several such institutions were surveyed to determine their level of environmental concern (measured by the New Environmental Paradigm (NEP) scale) and agreement with soft path principles. Results suggest that environmental concern and support for soft path principles are correlated, and study respondents exhibited both pro-NEP and pro-soft path responses.

I. INTRODUCTION

"All the water that will ever be is, right now"
National Geographic, October 1993

"It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change."
Charles Darwin

The Earth's population is rapidly increasing. At this time there are over 7 billion people on the planet, and that number is expected to rise to 9.7 billion by the year 2050 (United Nations Department of Economic and Social Affairs 2015). The increasing population will put additional strain on the Earth's already overstressed natural resources. The effects of carbon and other greenhouse gasses on the global climate are various and well known – with repercussions for both human and animal life. Water, as the foundation of life, is of particular importance to maintaining a healthy, functioning, planet.

A reliable source of water is the cornerstone for all successful human civilizations. From small rural farms supporting a single family to vast urban landscapes supporting millions, none would be successful without water. Yet all of the water that we will ever have is already present, it is not possible to add or create water. Overuse, over-allocation, and uneven distribution of water resources is already causing stress in many countries and cities worldwide. While there is no universal measure of water stress or scarcity, one common method is to use the amount of water available per individual in a population. Generally 1,700 cubic meters per person per year is considered the threshold for meeting water requirements for agriculture, industry, energy, and the environment. "Water scarcity" is determined to be at 1,000 cubic meters of available water per person, and availability below 500 cubic meters is considered "absolute scarcity". Many of the most water stressed countries are also experiencing very high population growth, resulting in rapidly diminishing per capita water availability. It is estimated that by 2025 more than 3 billion people may be living in water stressed countries, while 14 countries will transition from water stress to water scarcity (Watkins 2006).

Water systems are expected to be significantly impacted by climate change. Both major river floods and water scarcity are expected to increase. Changes in precipitation are anticipated – with high latitudes and the equatorial Pacific likely to experience an increase in annual mean precipitation, and mid-latitude and subtropical dry regions likely to experience a decrease in precipitation (Pachauri et al. 2014). Rising temperatures in existing agricultural centers will place additional stress on our water supply, as evapotranspiration will increase, thus increasing the amount of water needed for agriculture – an already water intensive process.

In the United States, water resource managers are attempting to address their future water needs in two major ways. First, they are securing as many new water supplies as possible (supply management). And second, they are attempting, with greatly varying levels of success, to reduce their per capita water consumption and maximize the use of their existing water supply (demand management/conservation). While these measures are worthwhile, there are limits to the gains that can be achieved with a supply and demand management focus.

Traditional water management focuses on supply. That is, how do we get the water from where it is, to where we need it to be? This involves the construction of dams, wells, pipelines, treatment facilities, and wastewater systems. The acquisition of additional water supplies is still the dominant solution pursued when shortages or anticipated shortages are identified. It is undeniable that a focus on supply results in some human benefits. Potable drinking water, delivery of water for irrigation or industrial uses, and hydroelectric power generation are all made possible through water infrastructure. However, supply management has, and will continue to have, undesirable impacts on the natural environment. Entire river systems have been slowed, polluted, and over-allocated. Natural habitats have been destroyed by the damming of rivers or the overuse and subsequent unavailability of previously available water. Water tables are sinking, and available groundwater is often becoming more difficult – and much more expensive – to extract.

A large portion of America's water supply infrastructure was built in the past 100 years, with steadily increasing numbers of projects and costs for those projects. In 1914 US investment in water mains totaled approximately $3 billion (monetary values are given in today's dollars). By 1920 (after World War I), the US was spending at more than twice the pre-war levels – approximately $10 billion annually. This number went down slightly during the Great Depression and World War II before rising again. By the start of the 1950's, water main investment had risen to $30 billion/year and was still growing. The original investment in US water infrastructure exceeds $2 trillion. Most of the systems relied upon today are now 50+ years old, requiring significant repair or replacement. While it is difficult to obtain precise figures, the US is spending an estimated $30 billion/year to make these repairs. The American Water Works Association (AWWA) report "Buried No Longer" predicts spending of about $1.7 trillion through 2050 just to accommodate pipe degradation and population change. This number does not include wastewater, storm water, or water treatment facilities (Curtis 2014). Clearly, a large amount of infrastructure and capital will still be required simply to move fresh clean water to our homes. Continued investment in this type of infrastructure will not go away. However, rising populations, climate change, historic overuse and mismanagement, and heavy population centers in historically arid lands have presented us with another problem – locating new water supply sources.

Construction of new supply projects can be expensive and time consuming. For this reason, common practice is to begin construction based on a projected need – before the demand for new water is critical. Since most projects only benefit a relatively small geographical area, water supply projects are typically financed by the benefiting region's water consumers. Convincing consumers that they should agree to fund something that they do not yet need can be a difficult task. Consumers often prefer to defer the costs associated with acquiring additional water supplies to the newcomers/projected residents whose presence resulted in the need for new water in the first place. This can be problematic, as construction of supply projects can take a great deal of time, and waiting until there is an immediate need for the water can result in years of shortage.

In addition to significant time and monetary expenditures, another potential issue with supply projects is the need to obtain land access and rights of way. Landowners can be reluctant to surrender all or portions of their property for the construction of dams or pipelines. There are many instances in the past – such as with Elbowoods, ND; Kennett, CA; Enfield, MA; Neversink, NY; Butler, TN; St. Thomas, NV; and Lake Amistad, TX to name a few – where entire towns, reservations, or archaeological sites were destroyed so that dams and reservoirs could be constructed (The Center for Land Use Interpretation 2005; Texas Beyond History 2008). Pipelines crossing private property are also contentious. Some landowners will agree to compensation from pipeline companies to allow them access to their land. Others, however, will refuse to sign any such agreements. In cases where agreement with the landowner cannot be reached, water suppliers may resort to eminent domain claims to secure the rights for their infrastructure. Eminent domain refers to the power of the state to seize private property without the owner's consent, for a "public use" such as utilities, highways, and railroads. The condemnation of one's land does not often endear the cause (e.g. pipeline) to the landholder.

Regardless of the potential problems involved, supply infrastructure is necessary and will continue to be so. New water supply projects are becoming increasingly crucial, but are difficult to fund and obtain approval for. In an effort to circumvent some of the problems associated with finding and delivering new water supplies, water providers are increasingly relying on conservation of existing water supplies. This is demand management.

Water utilities have realized that the cheapest "new" water can be provided by reducing demand on existing water supplies – water that is not used today is water available for tomorrow. Demand management can be thought of as a process or action that directly reduces the use of water (conservation), or makes more efficient use of an existing supply. These efforts are important, in that they both save money and help reduce the environmental impacts associated with the overuse of water. Unlike supply management, which tends to be centralized (e.g. a new water treatment plant, dam, or pipeline), demand management is largely decentralized. Most efforts at demand management happen at the household level through the use of water efficient appliances such as washing machines and dishwashers, fixtures such as shower heads and dual-flush or low flow toilets, and by efforts like planting drought resistant plants or xeriscaping. Other demand management strategies such as turning the water off while brushing teeth, taking short showers, and washing only full loads of laundry or dishes depend on each individual within a household.

Water demand management strategies can be employed very effectively and can result in significant water savings. Many appliance and fixture solutions simply require a one-time installation and then the conservation benefits begin to accrue. For individuals not fully engaged in the conservation process (i.e. individuals who do not care to make an individual contribution) these are ideal solutions for providing conservation benefits with minimal effort. Local water utilities commonly attempt to involve households in water conservation by providing free water efficient fixtures, or offering tax breaks, rebates, or other incentives for xeriscaping, removing lawns, using high-efficiency filter systems in pools, and removing or reducing existing irrigation systems. Gleick et al. found that the State of California could reduce indoor water use by approximately 40 percent by simply replacing remaining inefficient toilets, washing machines, showerheads, and dishwashers, and by reducing the amount of leakage. These gains could be realized without the need for improvements on existing technology (2003).

While both supply and demand management are essential components of water resources management, a more fundamental change in human behavior and motivation is needed to spur the drastic shift that will be required to provide for our ever-increasing population. A continuation of the status quo will see vast quantities of our resources depleted, polluted, or rendered inaccessible. We need to move beyond traditional supply and demand management, and change the way we look at water to create effective and long lasting change. Ensuring that our resources are used in a sustainable manner – that is, ensuring continued availability of the resource both now and indefinitely into the future for both humans and non-humans – should be considered a priority. To be effective, a sustainable approach to water management must become a way of life, not simply the means to save money on our water bill. We must work collectively towards solutions that will make a real difference. As fellow citizens on this planet, the global community needs to work together to promote sustainable, efficient, and ethical practices. (McAlpine et al. 2015). Looking beyond the realm of traditional supply and demand management, there is another potential water management strategy that can be considered – the water soft path. Embracing the water soft path will require a fundamental change in our motivations and behavior, effectively changing the way we look at water.

While water scarcity and water stress are global issues, the state of Texas has some characteristics that potentially increase its vulnerability. Texas is subject to both drought and flooding and contains a variety of climate regions, from arid deserts to coastal cities. With the exception of the eastern portion of the state, evaporation exceeds precipitation across most of Texas. The population in Texas continues to increase, and the effects of over-allocation of surface-water resources has resulted in an increased reliance on groundwater resources. There is a great deal of variation in the management of groundwater, and over-pumping has already caused issues such as land subsidence in some areas. While some groundwater management areas have turned to water rationing to preserve as much of this resource as possible, new water management strategies are needed to ensure continued availability in the face of rising populations and the changing climate.

The objectives of this study are:

1) *Explore the current water management strategies in San Antonio, TX and the potential impact of projected population increases and water shortages.*
2) *Identify the potential barriers and opportunities involved in fully implementing a water soft path approach in San Antonio, TX.*
3) *Correlate ecological beliefs/attitudes as measured by the New Ecological Paradigm (NEP) scale with the acceptance of water soft path principles in employees of local (San Antonio) and state (Texas) water management institutions.*

II. LITERATURE REVIEW

The Water Soft Path

Amory B. Lovins began the soft path discussion in 1976 with a focus on energy. Lovins compared hard path (supply) strategies with "soft path" strategies – that is, efficiency improvements and use of renewable resources. Soft path strategies look beyond increasing supply. The focus of the soft path is the type of services that will be required in the future, and the various ways in which those services can be provided. Soft path strategies are value focused – they take into account situational, environmental, social, and economic considerations instead of focusing solely on a real or perceived "need" (Brooks et al. 2009).

As with demand management strategies, the soft path encourages efficiency. It does not, however, stop there. There are four fundamental principles to the water soft path (Brandes and Brooks 2007):

- Water planning should be done via "backcasting".
- Ecological sustainability is a fundamental criterion.
- The quality of the water should be matched to the use of the water.
- Water is considered a service, not the end itself.

Backcasting

Backcasting can be described as setting a desired future goal, and then working backwards from that goal to determine how to get there. This is in contrast to forecasting, which takes existing (or theoretical) conditions and attempts to project how the future will look if those conditions persist. Backcasting is particularly useful when there is a need for major change. This process provides an alternative image of the future – one chosen by design as the most ideal for that scenario. With this future image in place, participants in the backcasting process then determine what steps need to be taken to move from the current reality to the desired reality. This type of information is designed to inform the policy making process, assisting in the creation of policies that will bring about the envisioned future (Dreborg 1996).

Ecological Sustainability

The soft path recognizes natural ecosystems as legitimate users of water. Water provides a vast number of ecosystem services that enable and enrich the lives of all individuals on Earth. The United Nations Environment Programme summarizes ecosystem services thusly:

> Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on earth.

A visual representation of common ecosystem services is found below in Figure 1.

Figure 1. Visual Representation of Common Ecosystem Services. Source: metrovancouver.org.

Ensuring the continued health of the ecosystems that provide us these invaluable services is an essential component of securing a healthy future for the human race. Callicott and Mumford defined ecological sustainability as “the maintenance, in the same place at the same time, of two interactive ‘things’: culturally selected human economic activities and ecosystem health” (1997). Ensuring that these two “things” coexist is a critical step in constructing a sustainable future. A more recent take on sustainability suggests that geography should be taken into account. Liu offers the definition of “living within one’s own ecological means”. In this definition “living” means meeting basic needs for human life, but not everything one needs or wants. “One’s own ecological means” is dependent on one’s own carrying capacity locally or regionally and includes a geographic dimension. “One” can be an individual, a community, a county, a region, a country, or the whole world (2009). Soft path solutions contain elements of both definitions, as they encourage economic and technological advances as a way of reducing reliance on existing water supplies, while acknowledging the need to tailor solutions to the specific circumstances of the target region.

Sustainability definitions have a tendency to assume that the Earth's resources will be sufficient to meet the present and future needs of humankind. This assumption encourages economic and technological development in the hope that the outcome will provide a better life for all (Liu 2009). Indeed, it has been suggested that technological advances will enable us to replace existing resources with other resources or technologies that perform the same function (Simon 1996). The primary way that technology can "replace" natural resources is in creating efficiency improvements, allowing for a lesser quantity of the resource to be consumed. Certain categories of ecosystem services, for example provisioning resources, have shown that technology can, in some instances, provide a replacement for ecosystem services. For example, new technologies are already assisting us in a transition away from our current level of dependence on fossil fuels for energy production. While some would argue that substitutes for ecosystem services such as air quality maintenance, fresh water, nitrogen fixation, pollination, and habitat provision are much less likely to be developed (Callicott and Mumford 1997), others believe that we have already developed such solutions in many cases (Fitter 2013). Water quality and water supply are two areas where Fitter argues that we have already identified technological solutions to replace natural processes (chemical treatment, desalination). It is, however, worth considering the impact of those technological advances that allow us to "replace" traditional ecosystem services. It is important to consider whether these alternative solutions are themselves sustainable. Desalination, for example, imposes a large energy cost, and the disposition of the resulting salt waste is problematic (Fitter 2013).

Considering the degree of interaction between human survival and naturally provided services, incorporating a focus on ecological sustainability into our water management paradigm is essential. To achieve ecological sustainability, soft path policies should consider not only the potential direct impacts to ecosystems, but also the impacts of the proposed technological solution. The preservation of ecosystem health should be one of the principle goals when setting forth new policy.

Addressing groundwater in particular, aquifer depletion can cause a number of potential ecosystem and human impact issues, including habitat destruction, the drying up of wells, increased pumping cost, reduction of water in surface water systems such as rivers, streams, and lakes, potential deterioration of water quality via saline water intrusion, and land subsidence to name just a few. These issues are dependent on the geography of the area in question, and considering the likelihood of each of these scenarios is an important factor in the development of policy solutions. Certain aquifers may be very vulnerable to saline water intrusion, for example, but less likely to experience dry wells. Soft path solutions would require a thorough understanding of the potential for these situations to occur, the likely damage to human and natural resources as a result, and the necessary steps to prevent or mitigate the situation.

Matching Water Quality and Use

It is important that we match the quality of our water to the purpose for which it is to be used. Very few uses – mostly for household tasks such as drinking, cooking, and bathing – require high quality treated or “drinking” water. Even though it is often not a requirement, most of the water we use is treated, and not of a lesser quality. Water intensive activities such as irrigation, power generation, and some industrial uses do not necessarily require high quality water to be completed effectively. Expanded use of recycled water, rainwater, and even brackish water (when the situation allows) will permit us to draw lesser amounts from our more traditional water sources. So, while per capita use may not be reduced by this method, we will be making more efficient use of our available resources. Since treating water is more expensive (in terms of both dollars and energy use) than not, matching the quality and use of our water provides the potential for significant savings of both energy and money, with the energy savings potentially resulting in environmental benefits as well.

Matching the quality and use of water may not always be possible. In rural, agricultural communities, for example, a large amount of the water used is for irrigation purposes. Many such users have personal wells, and thus there are fewer supply utilities to provide recycled water in larger quantities. As much as possible, it is still advisable to use a lesser quality of water for irrigation purposes, though infrastructure deficiencies may hinder this effort in some areas.

Water as a Service

> "If you go to the hardware store looking for a drill, chances are what you really want is not a drill but a hole. And then there's a reason you want the hole. If you ask enough layers of 'Why?'…You typically get to the root of the problem."
> Amory B. Lovins

Traditional demand management focuses on *how* – how can we accomplish specific tasks with less water? The soft path, however, focuses on *why* - why do we need water to accomplish this task in the first place? The focus on why greatly increases the number of potential solutions to our water problems. As discussed in connection with ecosystem services, it is entirely possible that human ingenuity can provide us with creative ways to accomplish tasks with little to no water usage, while still allowing us to maintain a high quality of life (Brooks et al. 2009). Examples of such technologies run a wide spectrum from techniques like drip irrigation, to composting and incinerator toilets, and dry shampoo.

With the exception of water used for drinking, washing, and maintaining ecosystems, the soft path does not view water as a final product. Water is, instead, looked at as a means to accomplish a specific task such as power generation, manufacturing, sanitation, or agriculture (Brandes and Brooks 2007). While not all uses of or services provided by water can be replaced with alternative methods, there is immense potential for technological advancement and greatly increased efficiency. Successful implementation of new technologies and efficiency measures has the potential to reduce per capita water demand, while widespread application of such successful methods could conceivably lower the bar for "water stress" or "water scarcity". The attainment of such results may ultimately lead to the improvement of global health and well-being. Considering how we can increase our efficiency and reduce demand by making use of new and existing technologies is an important step that water users of all kinds should be encouraged to perform. Focusing on the services provided by water – rather than on the water itself – provides a framework for the assessment of water dependent processes.

The city of San Antonio, TX poses an interesting case study for the water soft path. The population in San Antonio is expected to steadily increase over the next several decades, increasing the strain on the city's water resources. San Antonio is largely dependent on groundwater – the Edwards Aquifer – for its water supply, though use of the aquifer is strictly controlled in order to maintain habitat for several endangered species. The specific requirements for the aquifer do not allow for an increase in permitted withdrawals, forcing San Antonio to search for alternative water supplies. The following sections will discuss the current groundwater usage in San Antonio, and the ways that the soft path might be employed to increase water use efficiency and decrease the need to seek outside sources of water for the city.

Groundwater Use in San Antonio, TX

In order to improve groundwater management strategies in San Antonio through the use of soft path principles, we must first analyze present water usage. Thorough study of the way individuals use water will provide critical information to inform decisions about our future conservation and water replacement efforts. In the United States, total water withdrawals are estimated for eight separate categories of use: public supply, domestic, irrigation, livestock, aquaculture, industrial, mining, and thermoelectric power.

In Texas, total groundwater withdrawals are 23,657.27 acre feet (AF)/day. This total includes saline groundwater, however only the “Self-supplied industrial” and “Mining” categories count any saline withdrawals (majority from the Mining category) and this study will not focus on these categories. Total groundwater withdrawals in Texas are detailed in Figure 2 below (Maupin et al. 2010).

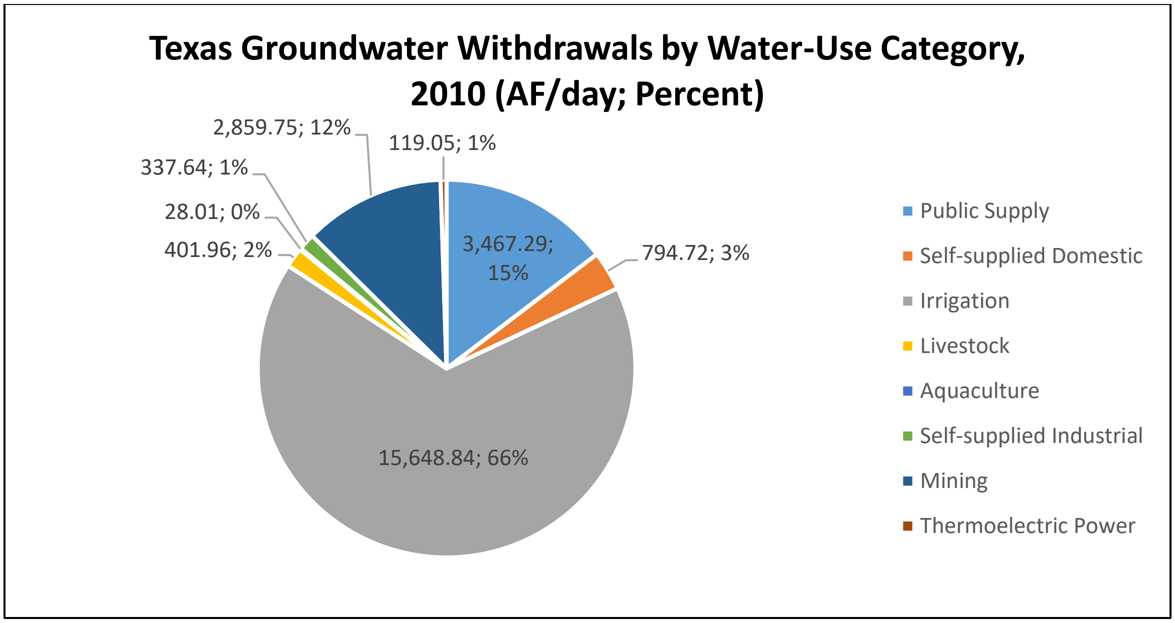

Figure 2. Texas Groundwater Withdrawals by Water-Use Category, 2010 (AF/day; Percent) Source: Maupin et al. 2010

Irrigation water use includes water applied by an irrigation system to sustain plant growth in all agricultural and horticultural practices, as well as water used for pre-irrigation, frost protection, application of chemicals, weed control, field preparation, crop cooling, harvesting, dust suppression, and leaching salts from root zones. Irrigation sources are considered fresh water and do not include irrigation completed with the use of recycled water. At this time, irrigation represents the largest groundwater use in the state of Texas by a large margin. While irrigation uses a significant amount of water, there are some encouraging developments. The states with the largest application rates for irrigation (California, Idaho, Colorado, Texas, and Nebraska) all showed declines in those application rates even though they all increased the number of acres irrigated by sprinkler or micro-irrigation systems in the time since the previous study in 2005 (Maupin et al. 2010).

While there is great potential for reducing the amount of water used for irrigation, the major focus of this study will be on the second largest category of groundwater use in Texas – public supply. In San Antonio, public supply of water is provided by the San Antonio Water System (SAWS). The majority of the water provided by SAWS is from groundwater sources – with the largest withdrawals coming from the Edwards Aquifer. The most recent data available indicates that in the first six months of 2016 SAWS had a total potable production of 108,827 AF of water from five different sources, as shown below in Figure 3.

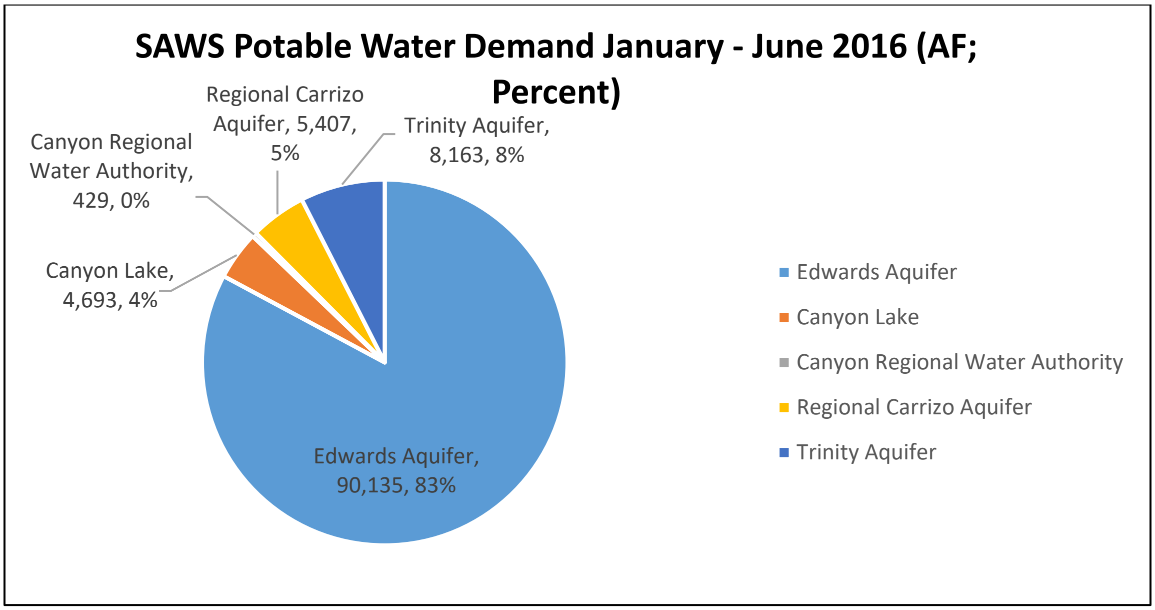

Figure 3. SAWS Potable Water Demand January – June 2016 (AF; Percent) Source: San Antonio Water System 2016

With the population in San Antonio expected to increase significantly – from approximately 1.5 million people in the year 2020, to approximately 2.4 million people by 2070 water use is set to rise – even if per capita use continues to decline (TWDB 2016). Projected municipal water demand for San Antonio is shown below in Figure 4.

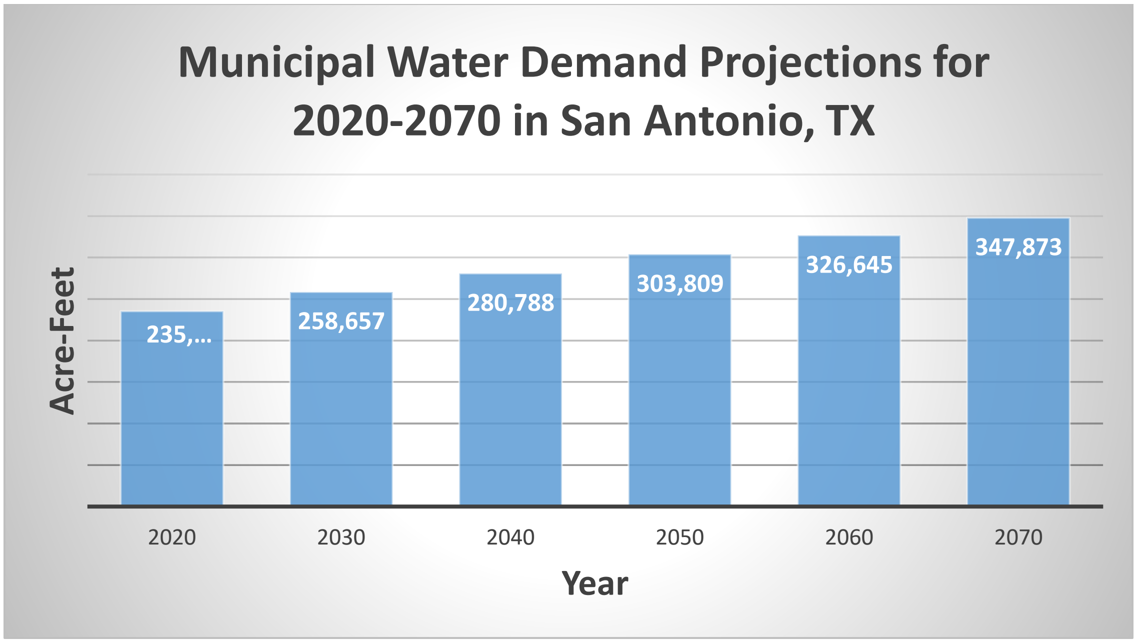

Figure 4. Municipal Water Demand Projections for 2020-2070 in San Antonio, TX. Source: Texas Water Development Board 2016

SAWS produced a water management plan in 2012 that is supplemented with bi-yearly updates. The plan discusses the strategies that SAWS will attempt to implement to ensure that San Antonio will avoid water shortages through 2040. The plan also provides a description of conservation measures they have or will implement in an attempt to reduce per-capita water use. At this time, SAWS boasts a 25% water consumption reduction since the 1980s using various conservation techniques. San Antonio has progressed from a usage high of 225 gallons per capita per day (GPCD) in the mid-1980s to the present 143 GPCD. Their professed goal is 135 GPCD under dry conditions by the year 2020 (SAWS 2012). Some of the conservation and rebate programs they have used to achieve current usage reductions are:

- Plumbers to people – in conjunction with San Antonio's Department of Human Services, SAWS provides qualified, low-income households with plumbing services to fix leaks at no charge. These repairs reduce water usage, and result in lower water bills for the resident.

- Free home checkups to assist customers in reducing their water use.
- Public communication and education efforts including: workshops, newspaper columns, radio call-in shows, events, and an e-newsletter.
- Pool filter replacement rebate for customers who replace sand or diatomaceous earth filters with a cartridge filter.
- Businesses can receive a rebate of up to 50% of the cost of installing water saving equipment.
- WaterSaver programs for hotels, laundromats, and restaurants to install water efficient appliances and fixtures and reduce consumption.
- Provision of free water saving fixtures to customers
- Rebates for reduction in irrigation, reduction in lawn area (addition of pavers), or xeriscaping (SAWS 2017).

While SAWS has had – and expects to continue to have – success in the use of demand management strategies, they choose to label them as supply management, saying: "The advanced conservation measures contemplated in this plan are identified as a supply, rather than an adjustment to the demand line. In this way, the community can more easily understand the magnitude of water supply development (and cost) avoidance provided by water demand management measures" (SAWS 2012).

As local and less expensive water resources reach capacity, municipal water providers are increasingly pursuing outside or non-adjacent water sources. Following this trend, and despite a significant decrease in per capita water consumption, SAWS is pursuing new sources of water for the City. San Antonio's new brackish groundwater desalination plant was opened in 2017. This plant treats water from the brackish Wilcox Aquifer, producing 12 million gallons of drinking water daily (13,441 acre-feet/year (AF/year)) – enough to supply 53,000 households (SAWS 2017). There are two additional phases in the construction and operation of the plant, and SAWS predicts that the plant's output will reach 30,525 AF/year by 2026 (SAWS 2012). Another program with several phases is the proposed expansion of SAWS use of the Carrizo Aquifer. By developing additional wells to extract freshwater from the Carrizo Aquifer, SAWS expects to add approximately 7,000 AF/year at the end of each of three phases (to be completed in 2017, 2022, and 2026) for a total of 21,000 additional AF/year at the end of the third phase (SAWS 2017). SAWS also has another large supply project in the works, known as the “Vista Ridge” pipeline. Vista Ridge projects to be the largest non-Edwards Aquifer water supply source in the history of San Antonio. Water from Burleson and Milam Counties to the northeast will travel a pipeline to San Antonio and provide SAWS with up to an additional 50,000 AF/year of water beginning in 2020 (SAWS 2016).

Between the Vista Ridge pipeline, the expanded use of the Carrizo Aquifer, the brackish groundwater desalination plant, and an effort to purchase additional rights to Edwards Aquifer water (an estimated additional 10,900 AF/year) SAWS expects an additional 110,937 AF/year in availability by 2026 (SAWS 2016). Even assuming the success of all of the supply and demand management strategies discussed, the water deficit in San Antonio is projected to steadily increase over the next 50 years from approximately 47,000 AF/year in 2020 to 155,000 AF/year in 2070 as pictured in Figure 5. The full application of the soft path paradigm in San Antonio has the potential to greatly reduce – or even remove this supply gap.

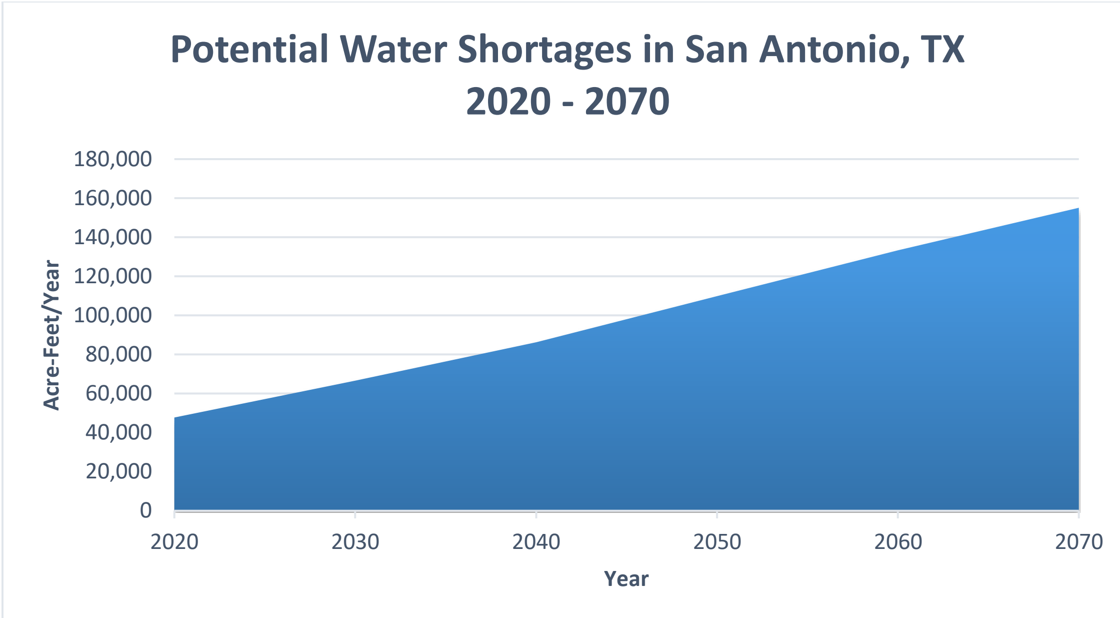

Figure 5. Potential Water Shortages in San Antonio, TX 2020-2070. Source: Texas Water Development Board 2017

While SAWS supply initiatives do meet the goal of increasing San Antonio's water supply, there are some drawbacks. Desalination is known to require large amounts of energy to complete, and disposal of the salt waste is difficult. Potential impacts on the Carrizo-Wilcox aquifer system as a result of new wells and the Vista Ridge project should also be considered. The Carrizo-Wilcox aquifer is composed primarily of sand, silt, and clay, and is much slower to recharge than a porous limestone aquifer such as the Edwards. The expanded pumping caused by the SAWS projects (and additional projects brought about by entities other than SAWS) will contribute to the drawdown of the aquifer beyond its recharge levels. This places residents currently relying on the aquifer system at risk of dry wells, increased pumping costs, and loss of their water source. The soft path approach would require an evaluation of each of these proposed methods, and the potential for human and environmental consequences as the result of their implementation.

The Soft Path in San Antonio, TX – Barriers and Opportunities

At this time, there is limited data available on the effects of the application of the water soft path paradigm. Three case studies completed in Canada – at the urban scale, watershed scale, and Provincial scale – as well as some supplemental studies in associated topics such as water use in food production, provide the bulk of currently available information. A look at the urban center case study illustrates the potential of the soft path for a city such as San Antonio. The urban center case study involved multiple medium sized Canadian cities, and was designed to be "generic" so that its results would be applicable across North America. The study looked at three future scenarios for water use in order to determine the potential of the water soft path in an urban setting. The future scenarios were: business as usual, demand management, and soft path.

The business as usual scenario calculated future water use based on projections of current water usage and projected population increases. This approach provides a baseline for the other two scenarios, allowing a comparison of the potential water savings. The demand management scenario was also based on usage and population projections, but included the incorporation of readily available demand management technologies and practices. It was determined that the demand management scenario resulted in water savings of approximately 24% over the business as usual approach. Finally, the soft path scenario used the backcasting approach to calculate a future with "no new water use" until the year 2050. This means that the cities involved would need to incorporate projected population increases of 75% without increasing water usage or beginning any new supply projects. The soft path scenario also applies demand management strategies such as water efficient fixtures and appliances, lawn watering restrictions, building code innovations, and education efforts. It moves further than demand management, however, by including more advanced technologies such as rainwater harvesting, water reuse and recycling, and waterless fixtures such as composting toilets. The soft path scenario was projected to yield water savings of almost 44% over the business as usual approach. This scenario resulted in less water usage in 2050 – with the 75% increase in population – than was being used at the time the study was conducted. Full application of the soft path approach would make the goal of "no new water" until 2050 entirely possible (Brooks et al. 2009).

In its 2012 Water Management Plan SAWS noted (SAWS 2012):

> It is clear that, even developing the full slate of planned projects, there could be up to approximately 101,000 acre-feet of permitted supply gap in the worst year of a future drought of record-like event that would need to be addressed.
>
> Some conceptual solutions are:
>
> - Ocean Desalination
> - Expansion of Brackish Desalination
> - Additional ASR capacity or ASR operations
> - **New future conservation paradigms** (Emphasis added)
> - Future Regional Water Project(s)

Fully implementing a soft path paradigm in San Antonio, and setting a goal of "no new water" until 2070 is one way that San Antonio could attempt to close its projected supply gap. The soft path approach would encourage the identification of alternative solutions to ensure an adequate future water supply rather than tapping in to new/alternative water sources. SAWS already brands the city of San Antonio as "water's most resourceful city", and with much of the foundation already in place, including infrastructure and conservation measures, San Antonio provides a natural experiment to study the implementation rather than the projection of soft path solutions. Attention to the progress that San Antonio has already made, as well as the potential gains that could result from embracing soft path principles, could provide a valuable example for other cities to follow in the effort to reduce per capita water consumption across the globe. What follows is a discussion of how soft path principles can be applied – and in some cases already are – in San Antonio, TX.

Backcasting in San Antonio

The state of Texas is divided into 16 Groundwater Management Areas (GMAs). Each GMA is required to submit a set of Desired Future Conditions (DFCs) to the state for the groundwater resources under their control. DFCs are defined as: “The desired, quantified condition of groundwater resources (such as water levels, spring flows, or volumes) within a management area at one or more specified future times as defined by participating groundwater conservation districts within a groundwater management area as part of the joint planning process” (Title 31). Some aquifers reside in multiple GMAs, and some GMAs are responsible for multiple aquifers. The DFCs, then, will vary between GMAs as they are dependent on the goals set for each area and the needs of each aquifer. Determining DFCs provides an opportunity to apply a backcasting approach to groundwater management, as demonstrated by the management of the Edwards Aquifer in San Antonio.

The primary water source for San Antonio, the Edwards Aquifer, is managed by the Edwards Aquifer Authority (EAA). The EAA has legislated responsibility through the Edwards Aquifer Authority Act (the Act) to manage the southern portion of the Edwards Aquifer and they have been directed to:

- Protect the water quality of the Aquifer

- Protect the water quality of the surface streams to which the Aquifer provides stream flow
- Achieve water conservation
- Maximize the beneficial use of water available for withdrawal from the Aquifer
- Recognize the extent of the hydro-geologic connection and interaction between surface water and groundwater
- Protect aquatic and wildlife habitat
- Protect species that are designated as threatened or endangered under state or federal law
- Provide for in stream uses, bays and estuaries
- Protect domestic and municipal water supplies
- Protect the operation of existing industries
- Protect the economic development of the State
- Prevent the waste of water from the Aquifer; and
- Increase recharge of water to the Aquifer

These are all specific goals that describe the desired future of the Edwards Aquifer, and include stipulations that provide for water quality, human use, and ecosystem protection and maintenance. The Act also specifies the amount of permitted withdrawals from the aquifer each year. Withdrawals may not exceed or be less than 572,000 AF/year (S.B. No. 1477). With this understanding of how the future of the Aquifer was envisioned, policy makers were able to work backwards from those requirements to design and implement a plan that would ensure that the stated goals were met. In determining how to meet this requirement, numerous factors were considered, such as precipitation recharge, aquifer discharge to surface water, annual groundwater use, population projections, flow into and out of the Aquifer, and projected water demand for all 8 categories (EAA 2010). The success of this approach in San Antonio clearly demonstrates that water quality, ecosystem, and human considerations can be accomplished simultaneously. A backcasting approach can be a valuable tool for entities with firm goals in mind.

By contrast, GMA 1 (Ogallala Aquifer), uses a method more akin to forecasting to set their DFCs. They calculated applicable pumping and recharge rates, and simply provided an estimate of the amount of water that would remain in the corresponding portions of the aquifer (varies by aquifer thickness). GMA 1 is moving forward with a "business as usual" approach. A backcasting approach could prove quite beneficial to GMA 1, as it would give them a target to work towards – something that could assist in bringing about a change in behavior. This example is particularly important in light of the fact that the Ogallala aquifer region (though this is not exclusively within Texas) produces around one-fifth of the US annual agricultural harvest. The potential consequences of this aquifer running out of water are extremely severe – yet in some portions of the aquifer it is already happening. While initial cost can be a concern, new and innovative conservation methods are not likely to be developed or deployed in a situation where they are not required (TWDB 2015).

There are some potential stumbling blocks in the application of a backcasting approach. To be truly effective, appropriate goals need to be set, and the method of attaining those goals should be innovative and concise. The success of the backcasting approach with the management of the Edwards Aquifer provides a framework for San Antonio to apply to additional water supply sources. Choosing a future time point (this study will use 2070 as an example), setting a goal of "no new water" until (at least) that time, then working through the steps it would take to reach that goal would be a valuable exercise that has the potential of transforming the way San Antonio looks at water. The application of the soft path principles discussed in this study could provide sufficient water savings for San Antonio to avoid the necessity of securing additional supply sources – a result with positive implications for both environmental and financial concerns.

Ecological Sustainability in San Antonio

Ecological sustainability and the Federal Endangered Species Act played an important role in setting the withdrawal conditions and limits on the San Antonio portion of the Edwards Aquifer. The knowledge that the use of Aquifer water has direct impact on important local ecosystems was a key planning tool for appropriate Aquifer management. The Act required the EAA to cooperate with other entities on a recovery maintenance program to develop a habitat conservation plan for those species listed as threatened or endangered under federal law and associated with the Aquifer. The Edwards Aquifer discharges as spring flow in Comal and San Marcos springs (among others). These springs provide habitat for several federally recognized threatened and endangered species. When the Aquifer level at the Bexar County index well (J-17) reaches 623 feet mean sea level (msl), the flow to these springs ceases – jeopardizing the habitat of these endangered species. With this in mind, the EAA adopted a Critical Period Management Plan (CPMP), which requires withdrawal reductions on permitted amounts when the Aquifer level drops below certain thresholds, as noted below in Table 3 (S.B. No. 1477).

Table 1. Withdrawal Reductions on Permitted Amounts Based on Aquifer Level

Comal Springs Flow Cubic Feet/Second (CFS)	San Marcos Springs Flow Cubic Feet/Second (CFS)	Index Well J-17 Level MSL	Critical Period Stage #	Withdrawal Reduction
<225	<96	<660	I	20%
<200	<80	<650	II	30%
<150	N/A	<640	III	35%
<100	N/A	<630	IV	40%

Table 1. Source: S.B. No. 1477

Each successive reduction is activated when the 10-day average level of the Aquifer falls below the stated level at the J-17 index well. The required reductions are achieved through curtailment of non-essential uses of water such as irrigation restrictions, pool cover requirements, and car wash restrictions. When stage IV is reached a drought surcharge is assessed on all water accounts used for landscape irrigation in addition to the requirements of the previous stages (S.B. No. 1477).

While they have successfully integrated ecological sustainability into their management of the Edward's Aquifer, SAWS can take steps toward greater overall ecological sustainability by evaluating their other water sources. Pipelines such as Vista Ridge require a great deal of infrastructure and can impact a large number of plants, animals, and humans in varying but significant ways. For example: Habitat for species of concern or for endangered species (both plants and animals) can be disrupted or destroyed, humans can be forced to surrender land (eminent domain), or lose access to their water supply as a result of pumping from the source aquifer, and aquifer depletion can result in reduced flows to surface water such as springs and rivers, impacting downstream users who rely on those water sources.

Federal projects require the submission of an Environmental Impact Statement (EIS) that examines the environmental, social, and economic impacts of the project. Some states have similar requirements. Texas notes that applications for the use of state water must include, among other things "any other information as the executive director or the commission may reasonably require". This can, at the discretion of the Texas Commission on Environmental Quality (TCEQ), include an EIS if one is available (TAC 1986). This requirement, however, applies to applications for state water and in Texas surface water (not groundwater) is owned by the state. An expansion of this rule to allow groundwater districts to require an EIS for certain projects (such as a pipeline) would encourage the collection and consideration of the potential impacts of such a project.

With a recent focus on acquiring new (non-Edward's Aquifer) water sources, it is important that SAWS ensures that any such sources maintain healthy ecosystems. Compliance with the Act and the Endangered Species Act required identification of the potential for harm to critical habitats, and the steps necessary to prevent that harm from occurring. Applying a broader focus to these strategies and considering the likely damage to all human and natural resources in the form of an EIS would help to identify additional areas where San Antonio can improve its environmental stewardship. Once potential ways to mitigate or prevent harmful environmental outcomes for San Antonio's other water sources have been identified, the backcasting approach can be used to determine how to best move forward.

Matching Water Quality and Use in San Antonio

There are multiple levels of potential solutions to matching water quality and use. From city-wide solutions to household choices this category has the potential to greatly reduce the amount of treated water used. As a large-scale solution, water supply utilities can incorporate water recycling programs to serve commercial users such as golf courses, parks, and industrial customers. These customers typically use large amounts of water for practices such as landscape maintenance, or industrial uses that do not require high quality treated water. Initial infrastructure development and expenditures will most likely be costly, but the benefits of such as system – including reduced energy and monetary output for water treatment, reduced demand for treated water, and more efficient use (re-use instead of one and done) of a limited resource – make the initial monetary output worthwhile.

San Antonio provides a great example of the successful implementation of a large-scale water recycling system, as SAWS provides the largest direct recycled water delivery system in the nation. Recycled water is piped to commercial users around the city, and is even used in the San Antonio River Walk – a feature that draws tourists from across the globe, and ultimately brings money back to the city. The water recycling system in San Antonio is made up of three components. First, the recycled water itself is piped across the city. The treatment of wastewater also produces biosolids – nutrient rich organic solids resulting from the treatment of sewage. San Antonio uses these biosolids to create compost, which is then sold commercially. Finally, San Antonio makes use of the biogas (which is largely composed of methane) that is generated during the treatment process. With a partner company, they treat a minimum of 900,000 cubic feet of gas per day, and transfer it to a commercial pipeline to sell (SAWS 2017). These types of commercial ventures offer potential offsets to the cost of system installation.

Admittedly, a large-scale water recycling program is not appropriate in every city or every situation. Under certain circumstances the re-use of water could result in a lesser amount of return flow for potentially over-allocated river systems, causing problems for downstream users. However, since this study is specifically addressing groundwater use and the primary source of water for San Antonio is groundwater, the issues of return flow are not as significant a factor as they may be elsewhere.

Though its water recycling program is a step in the right direction, San Antonio has the potential for additional water savings through smaller scale efforts at matching water quality and use at the household level. One such household solution is rainwater collection. Rainwater collection can be as simple as placing a barrel under a structure's gutter to collect water that runs off of the roof, or it can involve a large catchment system. In its Report to the 80th Legislature, the Texas Rainwater Harvesting Evaluation Committee provided data on potential rainwater collection amounts across Texas. Using an average roof size of 2000 square feet, and an average of 30 inches of rainfall per year for the City of San Antonio, a single rainwater harvesting system (with 80% efficiency) could collect 30,000 gallons of rainwater each year. Appropriate storage for rainwater to prevent algae buildup and to maintain it as a water source during periods of dryness is certainly a cost consideration. However, the application of these measures could greatly reduce the burden on existing – largely groundwater based – water supply sources. The report also notes that the quantity of water that could be collected via rainwater harvesting would constitute less than one percent of the state's streamflow, thus having minimal impact on the waters of the state (Texas Rainwater Harvesting Evaluation Committee 2006).

Rainwater is a versatile water supply, and can be used for a number of outdoor applications or filtered for in home use. In addition to the conservation benefit of reducing reliance on water utilities, rainwater collection provides other benefits that align with the soft path goal of ensuring ecosystem health. Collecting and filtering rainwater uses less energy than traditional water treatment, resulting in monetary savings as well. It can also help protect soils from runoff carrying chemicals or pollutants from impervious structures and ground cover. There are a number of well-designed rainwater collection systems available for installation, as this method is commonly used in areas where there are no public water utilities and a groundwater source is not available.

As part of its Groundwater Management Plan, the EAA has listed supporting rainwater harvesting efforts as one of their objectives. They provide brochures to all water permit holders, as well as at educational booths and the EAA office, describing the implementation and benefits of such a system (EAA 2010). Disseminating this information more widely and placing more emphasis on the use of such a system would be an excellent step towards achieving greater usage of this technique. In an effort to provide a monetary incentive, the State of Texas Tax Code also exempts rainwater harvesting equipment and supplies from state sales tax, and allows governmental taxing units the option to exempt part or all of the assessed value of property where water conservation initiatives are present (Texas Tax Code 1999).

Another household level method of matching water quality and use involves saving and reusing water from your sinks, showers, and washing machines (known as greywater), and is a fairly simple process. Greywater is diverted from these areas and passed through a filter. The filtered water can then be hooked up to a drip irrigation system and used for landscape watering, or can be made available via hose for uses like vehicle washing. In Texas, no permit is required for household greywater systems that produce less than 400 gallons per day. New home builders are specifically encouraged to install plumbing in a way that allows for the collection of greywater (Texas Health & Safety Code § 341.039).

Hermitte and Mace noted that San Antonio's reported annual (2004 – 2011) average residential outdoor water use figure was 7,713,879,696 gallons (23,673 AF). This figure comprised 25% of San Antonio's total water use, and amounted to 67 gallons per household per day (2012). (It should be noted that SAWS indicated that at that time their monthly totals had not yet been adjusted, which could result in a 1 to 2 percent change to annual totals.) Widespread installation of greywater systems not requiring permits (less than 400 gallons per day) could offset a large amount of the current outdoor water usage in San Antonio, reducing overall water use significantly. Even a 25% reduction in water use would completely account for the projected water deficit in 2020, and would account for 45% of the projected deficit in 2070.

As noted above, builders are encouraged to install plumbing in a way that makes it possible to install a greywater system. Research has shown that addition of a greywater system during new construction is the most cost effective way to implement this system (Yu et. al, 2014). Other cities have turned to building requirements to implement similar environmentally focused regulations. For example, South Miami has recently passed a law requiring all new homes built in the city to have solar panels (Teproff 2017).

Requiring instead of “encouraging” greywater system capabilities in new plumbing systems, and offering rebates and incentives to retrofit existing systems would free a significant portion of San Antonio’s existing water supply to be used for activities requiring high quality, treated water.

Something as simple as the billing practices of the local utility can make an impact on water usage. In some cases, simply being aware of their water usage provides families with incentive to conserve, but many utilities provide only a basic bill such as that seen below. This practice can lead to issues, as “the lack of information obfuscates both patterns of usage and potential dollar savings resulting from incremental reductions in use, which could otherwise motivate households to conserve water” (Inskeep and Attari 2014). Detailed billing is available with SAWS, but those individuals who manage their accounts online only receive a bill like the sample below. If detailed information with a usage tracker is desired, it requires searching for a full bill on the SAWS website. Making a detailed rather than a basic bill standard for all customers could result in additional water savings by providing customers with an easy way to evaluate and track their water usage.

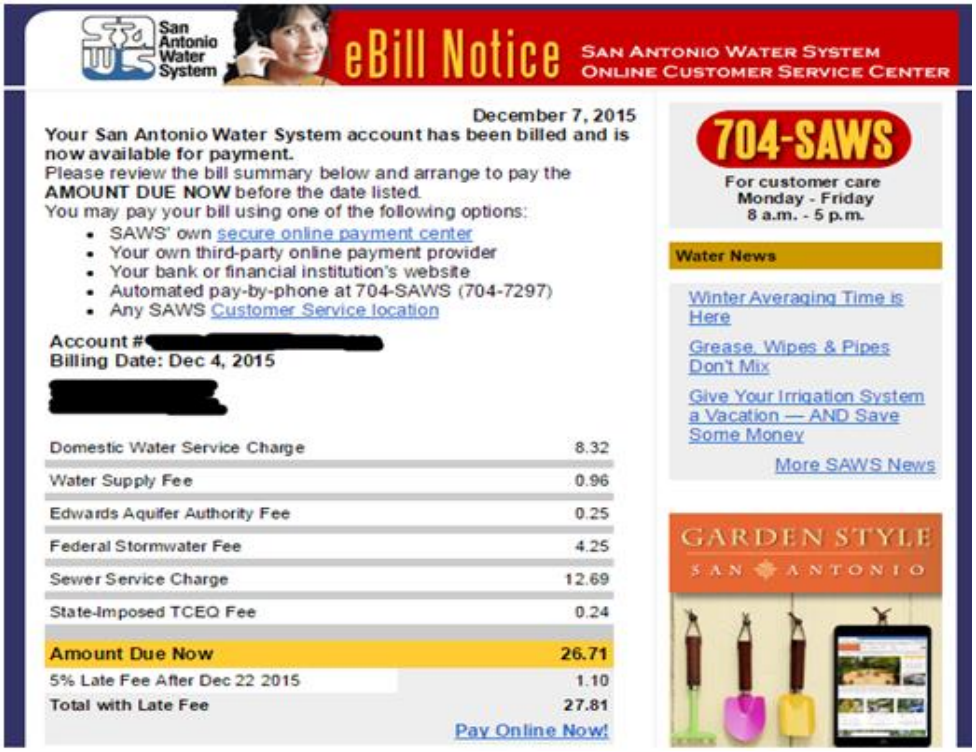

Figure 6. SAWS Water Bill. Source: SAWS Water Bill

There is a wealth of very valuable information about water saving measures, existing rebates, cost saving measures, and appliance innovations that could make electronic bills much more interactive and encourage greater public participation in conservation activities while increasing public knowledge. Since the installation of water efficient fixtures and appliances is one of the easiest ways to reduce water consumption, providing interactive tools on individual bills allowing users to estimate the water and cost savings they would accrue by installing a variety of fixtures or appliances might encourage homeowners to take steps to improve their efficiency. Calling attention to the rebates and incentives already in existence for some of these solutions and providing generic price ranges would allow consumers to choose solutions that fit their budget while maximizing their water saving potential. Easily viewable graphics on the state of the aquifer and the specific community and ecological benefits that result from reductions in water use may also increase participation in those programs.

While water conservation is a desirable goal, it is important to note that using less water means less money for water utilities. This is a significant barrier to conservation. Water rates are constructed so that they incorporate the cost of infrastructure maintenance, repairs, and any applicable supply projects in a water service charge. Additional state, sewer, and stormwater fees are added to obtain the monthly total (see sample SAWS bill, Figure 8). If utility customers begin to conserve too much water, the utility will then receive less money from consumers (reduced use = lower bills). Since the costs that the water supply fee is calculated to cover are often already spent, utilities are unable to lower rates for consumers as a reward for good conservation practices. On the contrary, since the reduction in water use results in less money coming in to the utility and they still have to pay for their supply and infrastructure expenditures, utilities are often forced to increase rates. This is understandably frustrating for customers, who find that despite their efforts to reduce water usage – often due to personal sacrifice or significang financial commitment on their part – they have been assessed *higher* rates.

Increased rates can have additional problems as in Texas, Water Supply Corporations (WSCs) such as SAWS are non-profit organizations (Public Utility Commission of Texas 2015). Raising rates to recover operating costs could result in a surplus of funds – which starts to look a lot like “profit”. Use of the water service fee to subsidize rainwater systems, greywater systems, appliance and fixture updates, and retrofits could reduce this potential impact. The use of the backcasting approach described above can provide a roadmap of goals and anticipated costs for such an undertaking, and excess funds can be saved and applied to these goals in succession. In this way, customers are investing both their personal time/resources (through conservation efforts as described) and their money in their water future.

Cost is always a significant concern in implementing new regulations, and it should be noted that monetary payback may not happen in the short term. This type of solution is looking ahead, so the initial cost of implementation may be higher than the resulting (monetary) savings. In this instance we are required to make a trade off. Do we want to save money – or water? It may not be possible to save both. If San Antonio were to commit itself to a soft path paradigm and seek to avoid acquiring new water sources for the city, it may be possible to direct funds previously targeted toward the acquisition and development of new supply projects to supplement some of the costs associated with the addition of new greywater systems, efficient fixtures and appliances, as well as toward retrofitting existing systems, thus offsetting some of the new costs at no additional expense to consumers.

Water as a Service in San Antonio

This facet of the soft path is all about perspective. We tend to think "I feel dirty, I need a shower" instead of "I feel dirty, I need to get clean". Getting clean does not necessarily rely on water – whereas taking a shower does. It is this change in perspective that will allow for the innovations necessary to point us toward a better water future. There are a number of steps that can be taken at both the household and the individual level to reduce or eliminate our water use for certain activities. In order to determine how to accomplish water-using tasks without, or with lesser amounts of water, we have to understand how our water is being used. The Residential End Uses of Water study

(REUWS) published by the American Water Works Association calculated the average water use in gallons per capita per day for a single family home. Results are shown in Figure 6 (Mayer et al. 1999).

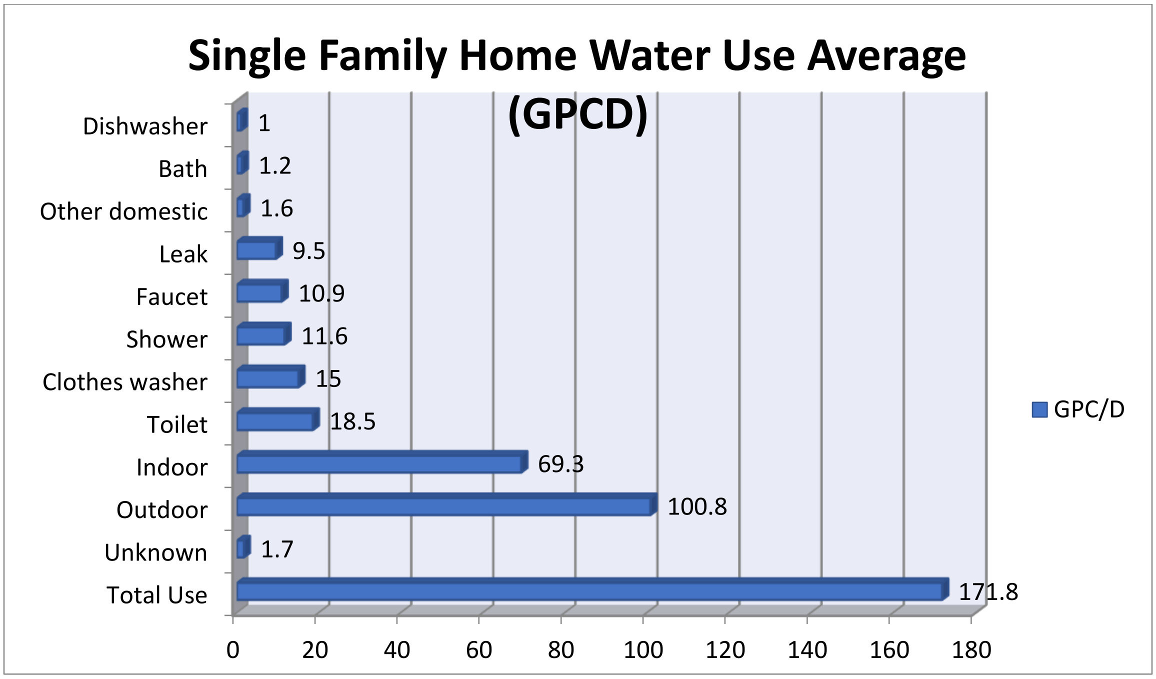

Figure 7. Single Family Home Water Use Average (GPCD). Source: REUWS 1999

As noted previously, outdoor use comprises the majority of total household water use. In the case of landscape irrigation, the desired service is a green lawn. Before we determine how to obtain a green lawn with less water, we should first consider why a lawn is needed. Xeriscaping or cultivating a “wild” lawn (no herbicides, pesticides or irrigation, minimal mowing, and encouraging wildflowers and weeds) would drastically reduce or eliminate the need for lawn irrigation in the first place. While we cannot eliminate the use of water completely in the maintenance of a traditional lawn, use of rainwater or greywater as described above will greatly reduce or eliminate the amount of “new” water needed for this application. Further reductions can be made by installing a permanent irrigation system and setting it to run early in the morning where less water will be lost to evaporation, and by using drip irrigation for gardens and flower beds. Since the outdoor use category consumes such a large amount of water, the potential reductions in per capita use from these methods can make a significant impact.

Indoor water use is divided into 8 categories. Figure 7 shows each category as a percentage of total indoor water use.

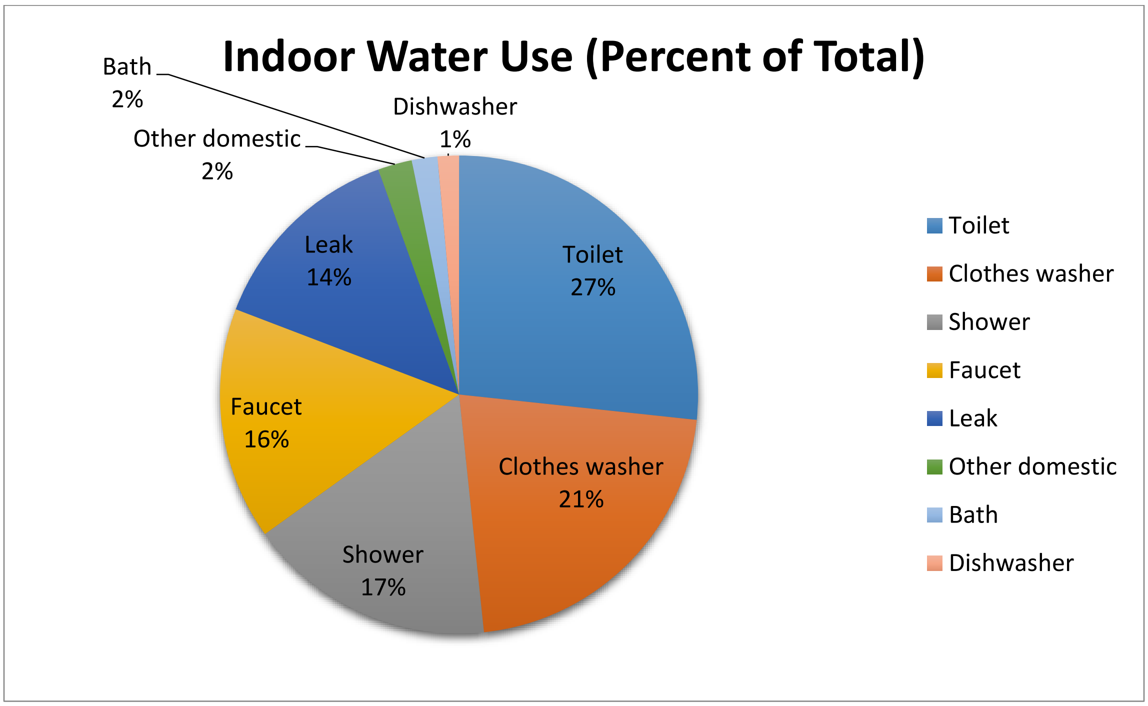

Figure 8. Indoor Water Use (Percent of Total). Source: REUWS 1999

There are options currently available to us that allow for the completion of household tasks without the use of water or with significant reduction in existing use. For example, we use up to an estimated 27% of our drinking water to flush our toilets. But, do we really need to use water to get rid of our waste? There are several waterless options available that, if implemented, would greatly reduce the amount of water used in the average home. Composting toilets and incinerator toilets are two examples of completely waterless systems that perform the same function as a conventional toilet – getting rid of waste (Nasr, 2009). At this time the most common usage of composting toilets is in rural areas that lack a traditional sewer system. A few characteristics of this system make it an unlikely solution for San Antonio at present. First, the "humus" (the product of the composting system) must be buried or removed by a licensed septage hauler, thus presenting homeowners with additional costs. Second, the larger systems require a basement for installation (Environmental Protection Agency 1999). Very few homes in San Antonio have basements, as the cost involved in blasting through the thick limestone prevalent in the area is usually more than homeowners or builders care to spend.

Incinerating toilets are used in the same type of circumstances as composting toilets, though with a different set of drawbacks. An incinerating toilet requires either an electric or natural gas connection to function. Both of these energy sources result in at least some pollution, in addition to higher average energy costs for the user (Environmental Protection Agency 1999). Precise operations standards are required to use these units correctly and safely, making them potentially undesirable for families with small children. While the two most common waterless waste disposal options are not necessarily the best option for San Antonio at this time, continued advances in these technologies could improve the likelihood of such solutions being adopted in the future. It is important to consider the desired result (removal of waste) rather than simply accepting that the only solution is water based.

Washing laundry is another significant source of water use, accounting for 21% of indoor usage. While dry cleaning is a waterless option for this task, it is cost prohibitive.

There are, however, products (e.g. Norwex Microfiber) available for purchase that do not require frequent washing. These products are available in many forms, such as towels, wash cloths, and kitchen scrubbers, and combine an antibacterial silver-based agent with their microfiber. The silver antibacterial fiber has purification properties, and is designed to inhibit bacterial odor, mold, and/or mildew growth within the cloth. Because of this, these products do not need to be washed as frequently as regular cloth products – which can result in water savings (norwex.biz). Wearing or using items more than once (on a case by case basis) before washing could also contribute to water use reductions. Another effective means of reducing water use in this category – at least for those with older washing machines - is to follow the demand management strategy of washing only full loads of laundry. Upgrading older washing machines to new units that are able to sense the load size and adjust the water level accordingly would increase efficiency without the need to change one's washing habits – potentially resulting in more concrete and lasting conservation benefits.

Approximately 17% of in-home water use occurs as a result of taking showers. We take showers to clean our body and hair, so the relevant question here is: is water necessary to clean ourselves? There are several dry shampoo options available, for example, that do not require the use of water to clean hair. Washing and conditioning hair constitute a significant portion of the time spent in the shower. Even occasional use of dry shampoo will greatly reduce the amount of water required to keep ourselves clean.

While most of the solutions discussed in this section are relatively simple, they can require costly equipment (load sensing washing machines, automatic irrigation systems, etc.) to implement, making it difficult for some households to commit to such strategies. The change in habits needed to drive the household and individual measures discussed will require a change in perspective from many individuals. The myth of water "abundance" produces a false sense of security – and does not encourage conservation tactics. The development of new technologies and innovations is often a long and costly process, and targeted innovation does not often happen without a perceived need to address. In addition to policy adjustments and technological innovations, the local community plays a very important role in the development and implementation of soft path principles. Accepting the need to plan for the future and absorb potentially higher rates is another challenge for the community. It is very important, then, that public education is made a cornerstone of the soft path approach. It should be noted that San Antonio's "small town" atmosphere (Burroughs 2014) has the potential to aid in community understanding and involvement. Effective community education and supporting grants or contests to further develop water use or conservation technologies could encourage greater participation and attempted innovation.

The transition to a soft path paradigm will not happen without hardship. A major barrier to the adoption of a soft path paradigm is support it will require to be adopted in the first place. Resistance to change can be difficult to overcome, decreasing the likelihood of implementing new practices. The first step in utilizing a soft path framework in San Antonio would require SAWS and other water management institutions to commit to a goal of "no new water", and to construct a road map via backcasting to determine the best way to achieve that goal. The individuals who craft water policy have to be willing to make this rather significant change, and commit to the course of action revealed by the backcasting exercise. Since San Antonio is already counting the savings gained through demand management strategies in the "supply" column, the use of additional techniques such as rainwater and greywater as discussed above could add significant savings to the "supply" column, easing the transition. Understanding how individuals in key water management institutions view soft path principles will provide some insight into the possibility of a soft path approach being implemented in San Antonio. Environmental worldview is often used in an attempt to predict behavior, and, given its focus on ecological sustainability and conservation programs we may learn about potential attitudes toward the soft path by looking at environmental worldview.

New Ecological Paradigm

There have been a number of attempts to measure the extent of an individual's environmental worldview, and studies frequently use worldview and environmental attitude as a way to predict the likelihood of future conservation behavior. Thompson and Barton attempted to measure environmental worldview by determining if individuals possessed an eco-centric or an anthropocentric attitude toward the environment. Individuals are said to have an eco-centric attitude when they value nature for its own sake and believe that it should be protected for its intrinsic value. Those with an anthropocentric attitude believe the environment should be protected because of its function in enhancing our quality of life. Individuals with an anthropocentric attitude toward the environment have been found to be less likely to protect the environment if other human-centric values such as the accumulation of wealth interfere, while those with an eco-centric attitude were more likely to conserve, and were more active in environmental organizations (1994). It is important to note that possession of an “anthropocentric” attitude as described by Thompson and Barton does not necessarily indicate an “anti-environment” stance. While the soft path clearly promotes the responsible use of water resources and places a great deal of importance on ecological sustainability, it also expresses considerable tolerance and even encouragement of anthropocentric ideals as well. It does not suggest that humans should “do without” as a way to improve environmental conditions. Instead, it encourages innovation and mindfulness of ecological concerns as a part of the policy process. A strict eco- versus anthropocentric definition of the soft path fails to capture the true scope of this paradigm. Since the soft path is being applied to a natural resource – water – and since it does encourage ecological sustainability, it is appropriate to consider environmental attitudes and worldview when discussing the potential acceptance and implementation of soft path principles. The New Ecological Paradigm (NEP) scale has been found to be a significant predictor of individual’s environmental concern (Liu et al. 2014)

The NEP scale is an updated and revised version of Dunlap and Van Liere’s New Environmental Paradigm Scale originally published in 1978. The original and revised NEP scales are the most widely used measures of pro-environmental orientation/world view, and environmentalists have been shown to possess higher scores on the NEP scale than the general public and members of non-environmental interest groups. Items on the NEP scale were designed to address five facets of an ecological worldview: the reality of limits to growth, anti-anthropocentrism, the fragility of nature’s balance, rejection of exemptionalism – which is the belief that humans are “exempt” from environmental forces due to their capability to adapt via cultural change - and the possibility of eco-crisis (Dunlap et al. 2000). The NEP worldview is characterized by individuals who are concerned about environmental protection, and believe that nature has the right to exist regardless of human benefit. The NEP consists of a 15 item Likert scale with possible scores ranging from a minimum of 15 to a maximum of 75. Scores exceeding the median of 45 indicate a higher degree of environmental concern.

While Dunlap et al. caution against expecting a strong relationship between NEP results and behavior (2000), several studies have found that environmental values are significantly related to behavior. Kaiser et al. found that environmental knowledge and values are significant preconditions of ecological behavior intention, though they did not measure actual pro-ecological behavior (1999). The NEP has been shown to be a reliable predictor of participation in water conservation activities, and has been shown to be a fundamental variable in explaining pro-ecological behaviors (Wolters 2014; Lopez and Cuervo-Arango 2008).

Clark, Kotchen, and Moore studied the link between the NEP and pro-environmental behavior through a group of Michigan residents who voluntarily participated in a green electricity program. Since participation in this program required a monetary contribution, it provided a natural forum to study pro-environmental behavior. Participants were asked to complete a portion of the NEP scale, an altruism scale, and additional questions. After controlling for altruistic attitudes, pro-environmental attitudes were found to independently influence the decision to participate in the green energy program, signifying a link between pro-environmental values as measured by the NEP and pro-environmental behavior (2003). With a focus specifically on water conservation, Corral-Verdugo noted that individuals in a city that did not experience water scarcity had more anthropocentric beliefs regarding human-nature relations and more utilitarian beliefs with regard to water use than individuals in a water-restricted city. Individuals in a water-restricted city reported more motivation for conserving water (2002).

Numerous studies have attempted to isolate the demographic characteristics that influence an individual's environmental worldview or level of environmental concern – often in conjunction with the NEP scale. Some of the more consistent attributes that tend to be related to environmental worldview are age, education level, and political ideology.

Younger individuals are seen as less integrated into the predominant economic and social systems, making the institutional changes that are often necessary to further the environmental movement less troublesome for these individuals. The majority of research findings have suggested that age is negatively correlated with an individual's level of environmental concern (Van Liere and Dunlap 1980; Klineberg et al. 1998; Mohai and Twight 1987). Interestingly, one study used data from 3 US national surveys taken in 2004, 2007, and 2013. Age was not a significant factor in determining environmental concern in the 2004 survey. However, age was a significant influence in the 2007 and 2013 surveys. In those 2 years, age showed a positive rather than a negative relationship with environmental concern, contrary to findings from many earlier studies (Liu et al. 2014). A British study also found a positive relationship between age and environmental concern (Clements 2012).

The same British study also found a positive relationship between educational attainment and concern for the environment (Clements 2012). A study in Texas conducted by Klineberg et al. found that age and education were the only two demographic variables consistently correlated with environmental concern, with age having a negative relationship and education a positive one (1998). Mohai and Twight also found age (negative) and education (positive) to be significant variables correlated w/ environmental concern (1987). Three studies of national survey data in the US, however, found education to have little or no influence on environmental concern (Liu et al. 2014).

Political liberals are often thought to possess higher levels of environmental concern than political conservatives. The reasoning behind this theory is that environmental policies can be costly and are generally not supported by business and industry, policies often require the extension of governmental control over the private sector, and they often require drastic action or the adoption of an "environmental ethic". Political conservatives display greater opposition to increased regulations, have a more "pro-business" stance, and have generally been less innovative in the use of government action to address societal problems than political liberals, thus providing a potential basis for their lack of support for "pro-environment" measures. Political liberals were found to have a greater interest in environmental issues, have an increased likelihood of taking environmental action, possess a higher level of approval for the environmental movement, and were more likely to express a pro-environmental attitude and engage in or express support for environmental actions (Dunlap 1975).

Klineberg et al found that political ideology was consistently related to those questions that weighed environmental protections with the need for increased regulations and government intervention (1998). National survey data results found self-assessed liberal-conservative position to have a statistically significant influence on environmental concern, with political conservatives being less concerned about the environment than political liberals (Liu et al. 2014). Uyeki and Holland found a significant relationship between “pro-environment” individuals and education, income, and political party identification. Interestingly, they found that democratic individuals with less education and lower income were more pro-environment than Republicans with more education and higher incomes. This study did include a variable for political ideology, but that was not found to be significant (2012).

Despite some outlying studies, young, well-educated, and politically liberal adults have consistently been found to hold a more pro-ecological worldview than their counterparts (Dunlap et. al. 2000). Fishbein and Ajzen suggest that when investigating the link between attitude and behavior, they should be addressed at a corresponding level of specificity (1975). Corral-Verdugo, Bechtel, and Franjo-Sing surveyed a sample of households in two cities in Sonora, Mexico using a combination of the NEP scale, an eight question scale designed to assess environmental beliefs pertaining specifically to water conservation, and direct observation of water use behavior in participating households (participants trained to register how many times and how many minutes each of five water using activities were performed). They felt that if general beliefs such as pro-NEP responses correlated with the specific beliefs on water conservation, which in turn correlated with the water consumption measures, then those general beliefs could predict conservation behaviors. They found a significant link between certain environmental beliefs and the specific behavior of water conservation, and supported the idea that beliefs predict behavior when they are assessed at a corresponding level of specificity (2003). With this in mind, I developed a nine question Likert scale to determine an individual’s level of agreement with water soft path principles. This scale was paired with the full 15 question NEP scale to determine if agreement with the soft path scale correlated with general pro-environmental values.

This study will investigate the following hypotheses:

1) Individuals with high scores on the NEP scale will have higher scores on the soft path scale.
2) The survey population – employees in water management institutions – deal with water conservation issues in a professional capacity, so the majority of respondents will have pro-NEP and soft path scores.
3) Young individuals will have a higher NEP and soft path score than older individuals.
4) Individuals with a Bachelor's degree or higher will have a higher NEP and soft path score than individuals with an Associate's degree or less.
5) Individuals who identify as liberal (slightly, liberal, or extremely) will have a higher NEP and soft path score than individuals who identify as middle of the road or conservative.

III. METHODS

Prior to initiating data collection, a pre-test survey was conducted to determine the reliability of both the NEP scale and the soft path scale. The soft path scale used for the pre-test contained 12 items, 3 of which were dropped from the final questionnaire to improve the reliability of the scale. Pretest alpha reliability values for the NEP scale were 0.720, and pretest alpha reliability values for the soft path scale (final, 9 question version) were also 0.720.

As noted in the discussion of demand management strategies, it is often the work of individuals that make up the bulk of demand management/conservation efforts. These individual efforts can be hampered by a number of factors such as lack of time, money, initiative, and understanding. Taking these difficulties into consideration, government policy can often be the catalyst that initiates conservation efforts. Nilsson et al. found that environmental value orientations were significantly related to attitude toward the text and acceptance of policy intervention methods (2016). Since the transition to a soft path paradigm would require the use of policy to implement, and the level of an individual's environmental concern can help identify that individual's potential for pro-environmental behaviors, I surveyed the city and state water management institutions serving San Antonio, TX to discover the predominant environmental worldview of their employees. These are the individuals who will be responsible for crafting and implementing water policy for the city of San Antonio, and their value orientations may impact the direction that the city takes.

This study relies on survey data collected from employees of local and state water management institutions in San Antonio, TX, including:

- San Antonio River Authority – Seeks to protect and enhance creeks and rivers in a 3,658 square mile jurisdiction that includes the City of San Antonio.
- Texas Water Development Board – Seeks to provide leadership, information, education, and support for planning, financial assistance, and outreach for the conservation and responsible development of water for Texas.
- San Antonio Water System – Seeks to deliver sustainable, affordable water services to its customers.

The Edwards Aquifer Authority was also contacted, but did not respond to requests for participation in this study. Each institution was contacted individually via email, with a brief description of the study and a request for participation. After agreeing to participate, each institution was provided with an introductory letter (See Appendix B) and a link to the survey site that was sent to the entire organization. The survey was anonymous and completely voluntary. Consent to participate was granted by clicking the survey link.

IV. RESULTS

Survey respondents were evenly split between males and females at 47.13% each, with 5.75% of respondents declining to identify gender. Almost all were over the age of 25, with only 4.55% falling below that threshold. The largest group of respondents (36.36%) was in the 26-35 age group. The majority of respondents identified their race as “White/Caucasian” (68.60%), with the next highest group identifying as “Hispanic/Latino” (12.79%). A large majority of respondents possessed a Bachelor’s degree or higher (84.89%), with over half of those individuals (53.49%) possessing a graduate or professional degree, or a doctorate. 42.35% identified their political ideology as some degree of liberal (extremely, liberal, or slightly), 20.00% identified as “Middle of the Road/Moderate”, and 28.28% identified as some degree of conservative (extremely, conservative, or slightly), while 9.41% declined to provide this information.

Survey response rates to the NEP portion of the questionnaire are provided in Table 2. Taken individually, the majority of the survey items elicited a “pro-NEP” response. That is, they expressed agreement with NEP values contributing to a pro-ecological worldview. Only two survey items did not receive a pro-NEP response. Item 2 (Humans have the right to modify the natural environment to suit their needs) received the majority of its responses (42.70%) in the neutral “neither agree nor disagree” column, and item 6 (The Earth has plenty of natural resources if we just learn how to develop them) received a majority of responses that were not pro-NEP (46.59%).

Table 2. Frequency Distributions for New Ecological Paradigm Scale Responses[a]

Do you agree or disagree[b,c] that:	1	2	3	4	5	N
1. We are approaching the limit of the number of people the earth can support.	5.62%	15.73%	31.46%	25.84%	21.35%	89
2. Humans have the right to modify the natural environment to suit their needs.	10.11%	22.47%	42.70%	22.47%	2.25%	89
3. When humans interfere with nature it often produces disastrous consequences.	1.12%	10.11%	23.60%	34.83%	30.34%	89
4. Human ingenuity will insure that we do NOT make the Earth unlivable.	12.36%	25.84%	31.46%	25.84%	4.49%	89
5. Humans are severely abusing the environment.	1.12%	8.99%	16.85%	34.83%	38.20%	89
6. The Earth has plenty of natural resources if we just learn how to develop them.	5.68%	19.32%	28.41%	30.68%	15.91%	88
7. Plants and animals have as much right as humans to exist.	2.27%	3.41%	12.50%	34.09%	47.73%	88
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.	35.23%	37.50%	20.45%	4.55%	2.27%	88
9. Despite our special abilities humans are still subject to the laws of nature.	0.00%	2.27%	10.23%	27.27%	60.23%	88
10. The so–called "ecological crisis" facing humankind has been greatly exaggerated.	38.64%	31.82%	23.86%	4.55%	1.14%	88
11. The Earth is like a spaceship with very limited room and resources.	2.33%	11.63%	22.09%	30.23%	33.72%	86
12. Humans were meant to rule over the rest of nature.	38.37%	32.56%	17.44%	6.98%	4.65%	86
13. The balance of nature is very delicate and easily upset.	2.33%	12.79%	26.74%	41.86%	16.28%	86
14. Humans will eventually learn enough about how nature works to be able to control it.	21.18%	41.18%	23.53%	12.94%	1.18%	85
15. If things continue on their present course, we will soon experience a major ecological catastrophe.	1.16%	11.63%	17.44%	36.05%	33.72%	86

[a] Question Wording: "On a scale from 1 (strongly disagree) to 5 (strongly agree), please indicate how much you agree or disagree[b] with the following statements."

[b] Agreement with the eight odd-numbered items (1=Strongly Disagree, 2=Somewhat Disagree, 3=Neither Agree nor Disagree, 4=Somewhat Agree, 5=Strongly Agree) indicate pro-NEP responses.

[c]Disagreement with the seven even-numbered items (items were reverse coded so that 1=Strongly Agree, 2=Somewhat Aagree, 3=Neither Agree nor Disagree, 4=Somewhat Disagree, 5=Strongly Disagree) indicate pro-NEP responses.

Responses to the soft path scale are provided in Table 3. As with the NEP portion of the survey, most individual responses indicated agreement with soft path principles. Only item 4 (Future projections based on current data are the best tool for deciding how our resources should be used) did not receive a pro-soft path response (62.06%). It is possible that the wording of this statement and the lack of an alternative example (Future projections based on current data provide a better tool for deciding how our resources should be used than setting a specific goal and then determining how to reach it) contributed to the low pro-soft path score.

Table 3. Frequency Distributions for Soft Path Scale Responses[a]

Do you agree or disagree[b] that:	1[c]	2	3	4	5	N
1. The natural environment provides us with many important services such as flood control, water purification, and carbon storage.	0.00%	6.90%	4.60%	29.89%	58.62%	87
2. Without major change we are at risk of critically depleting our natural resources.	1.16%	2.33%	20.93%	30.23%	45.35%	86
3. Using recycled or lesser quality water for some tasks can provide valuable cost and energy savings.	0.00%	0.00%	5.75%	21.84%	72.41%	87
4. Future projections based on current data are the best tool for deciding how our resources should be used.	2.30%	5.75%	29.89%	51.72%	10.34%	87
5. The preservation of ecosystem health should be considered when making decisions relating to the use of our natural resources.	1.12%	0.00%	6.74%	21.35%	70.79%	89
6. Natural ecosystems are legitimate users of water.	0.00%	0.00%	11.49%	24.14%	64.37%	87
7. Knowing how to do something is more valuable than understanding why it is being done.	27.59%	35.63%	29.89%	3.45%	3.45%	87
8. Having a specific goal can help initiate a change in behavior.	0.00%	2.33%	17.44%	47.67%	32.56%	86
9. Healthy natural ecosystems are not necessary for humans to flourish	65.52%	20.69%	8.05%	2.30%	3.45%	87

[a] Question Wording: "On a scale from 1 (strongly disagree) to 5 (strongly agree), please indicate how much you agree or disagree[b] with the following statements."

[b] Agreement with items 1, 2, 3, 5, 6, 8 and disagreement with items 4, 7, and 9 indicate pro-soft path responses.

[c]1=Strongly Disagree, 2=Somewhat Disagree, 3=Neither Agree nor Disagree, 4=Somewhat Agree, 5=Strongly Agree

Cronbach's alpha reliability analysis of the 15 NEP items yielded an alpha value of .803, while the soft path portion of the questionnaire yielded an alpha value of .637. This soft path value is lower than the pre-test value of .720. This difference in values may be a result of the wording of the questions in the soft path scale. The alpha value is a property of the scores from a specific sample of respondents, and it is possible that the difference in value from the pre-test to the final survey is a function of the chosen survey group (employees of water management institutions). Alpha value is also affected by the length of the test, with shorter tests potentially reducing alpha values. The soft path survey was only nine questions long and this may have also had an impact on the alpha value – though the survey length did not affect the pre-test value (Tavakol and Dennick 2011). Finally, the composition of the questions in the soft path scale ensured that each of the four primary principles of the soft path was addressed. Further refinement of the questionnaire, while maintaining relevance to soft path principles, may result in a more reliable measure. There is no real metric for judging the use of Cronbach's alpha, but the adequate level of reliability should depend on the decision to be made with the scale (Cortina 1993). Early work by Nunnally recommended an alpha value of .50 - .60 for early stages of research, though this recommendation was later increased to .70 (1967). At this time, as this is a preliminary study and no specific decisions will be made based on the results, the .637 Cronbach's alpha value, though considered low, will be used.

Hypothesis 1 predicted that individuals with high scores on the NEP scale would also show high scores on the soft path scale. A Pearson Correlation test shows a significant positive relationship between the NEP and soft path scales ($r=.508$, $N=84$, $p<.01$).

Table 4. Pearson Correlation Results Between NEP and Soft Path Scales

		NEP Scale	Soft Path Scale
NEP Scale	Pearson Correlation	1	0.508
	p		0.000
	N	85	84
Soft Path Scale	Pearson Correlation	0.508	1
	p	0.000	
	N	84	86

Hypothesis 2 predicted that the majority of respondents would have pro-NEP and soft path scores. Each question was scored on a 1-5 Likert scale, so a response average over 3 would indicate pro-NEP/soft path responses. Respondents showed pro-NEP (M = 3.7318, SD = .52835) and pro-soft path (M = 4.1189, SD = .42053) scores. These results confirm hypothesis 2. While study results confirmed a significant positive relationship between NEP and soft path scores, the soft path, while encouraging ecological sustainability, also has a significant focus on improving technology and the lives and comfort of humans. Survey questions were designed to capture the major points of the soft path, and the ecological and human focused balance of the soft path may have contributed to both the high average score for the soft path portion of the survey, and the fact that the soft path average score was higher than the NEP average score.

Table 5. Mean Scores for NEP and Soft Path Scales

	NEP Scale	Soft Path Scale
Mean	3.7318	4.1189
Standard Deviation	0.52835	0.42053

Hypothesis 3 began addressing demographic variables, and predicted that younger individuals would have higher NEP and soft path scores than older individuals. The age of 35 was used as the dividing line between “younger” and “older” for this study. Individuals aged 35 or younger would be less likely to be so settled in to their careers that they would be unlikely to accept significant changes. An independent sample T-test indicated that age was not a significant variable in the determination of NEP and soft path scores. This result is in line with some of the more recent research, suggesting that age differences in environmental concern/worldview are flattening out. This may be due in part to a higher level of understanding of our environmental issues, and to a greater degree of exposure to environmental information, “green” solution marketing strategies, and highly publicized campaigns to “save” our water, air, endangered species, etc.

Table 6. Effects of Age on NEP and Soft Path Scale Scores (Independent Sample T-Test)

		Mean (Standard Deviation)	t	p
NEP Scale	Age Under 36	3.7725 (.46829)	0.314	0.755
	Age 36 and Over	3.7348 (.57110		
Soft Path Scale	Age Under 36	4.1605 (.38986)	0.237	0.814
	Age 36 and Over	4.1389 (.41926)		

Hypothesis 4 continued addressing demographics, and predicted that individuals with a Bachelor’s degree or higher would have higher NEP and soft path scores than those with an Associate’s degree or less. Again, an independent sample T-test was performed. In this instance, education level was not found to have significant impact on the results of the NEP scale. As with age, it is possible that the ready availability of information about the environment, and ease of accessing such information via the internet may have leveled out the differences in this category. It is also important to note that a significant majority of the survey population (approximately 85%) had at least a Bachelor’s Degree. A more balanced survey population may have resulted in a more pronounced difference between the two categories.

Interestingly, education was a significant factor in agreement with the soft path scale. As noted above, a significant portion of the survey population had at least a Bachelor’s degree, so a more balanced population may not have seen such differences. Questions on the soft path survey specifically addressed water and natural resources use. These more focused questions may have elicited greater agreement than the general NEP questions due to the survey population's status as employees of water management institutions. Many of the specific issues addressed in the survey are very relevant to their respective institutions.

Table 7. Effects of Education on NEP and Soft Path Scale Scores (Independent Sample T-Test)

		Mean (Standard Deviation)	t	p
NEP Scale	Less than Bachelor's Degree	3.6600 (.66552)	-0.559	0.578
	Bachelor's Degree or Above	3.7615 (.51856)		
Soft Path Scale	Less than Bachelor's Degree	3.8642 (.37176)	-2.254	0.027
	Bachelor's Degree or Above	4.1781 (.39663)		

Hypothesis 5 centered on political ideology, and predicted that individuals who identified as liberal (slightly liberal, liberal, or extremely liberal) would have a higher NEP and soft path score than individuals who identified as middle of the road or conservative. The analysis of variance indicated that political ideology had a significant effect on NEP results ($F (2, 72) = 6.487$, $p < .01$). Political ideology, however, was not significant with respect to soft path scores. One of the reasons that political ideology is hypothesized to be a significant factor in environmental worldview is the regulatory burden that can result from attempts to control things like pollution, carbon emissions, resource depletion, etc. It is possible that since the survey participants are employed by water management institutions, they are less likely to object to policy and infrastructure needs for water management, thus removing one potential reason for disagreement with pro-environmental statements. Ideology's lack of significance to soft path scores is encouraging, suggesting that political differences may not be a stumbling block to the implementation of a soft path paradigm.

Table 8. Effects of Political Ideology on NEP and Soft Path Scale Scores (Analysis of Variance)

		Mean (Standard Deviation)	F	p
NEP Scale			6.478	0.003
	Liberal	3.9148 (.47931)		
	Moderate	3.8583 (.41731)		
	Conservative	3.4551 (.55946)		
Soft Path Scale			1.809	0.171
	Liberal	4.2315 (.37691)		
	Moderate	4.2500 (.30765)		
	Conservative	4.0694 (.36162)		

V. DISCUSSION AND CONCLUSION

While traditional supply and demand management strategies continue to have a place in our management of water resources, it is increasingly evident that the implementation of a new paradigm is needed. Water supply projects significantly impact human and natural systems, and it is becoming difficult to find and approve new large scale water projects due to concerns about water scarcity and sustainable supply. This study considered the soft path paradigm as a potential solution for the City of San Antonio, TX. To implement a soft path paradigm, SAWS will need to cease its search for new water supply sources and make a commitment to “no new water” until 2070. The backcasting approach can then be used to determine how to best meet that commitment. Solutions should include plans to expand on current demand management strategies by updating building codes to require the installation of greywater systems, rainwater catchment systems, and high efficiency fixtures and appliances. SAWS currently provides businesses with a 50% rebate toward the cost of water saving equipment. Extending those rebates to homeowners, and making it clear what the different types of systems are capable of, could greatly increase residential use of critical water saving technology. It may also be possible to use water supply funds to supplement retrofitting existing systems to include greywater systems, rainwater systems, and high efficiency fixtures/appliances.

Soft path solutions will require a drastic change from the current water management paradigm, and do not come without risk. There will be significant costs involved in subsidizing and incentivizing the necessary upgrades and retrofits. So, even without obtaining new water sources, there may not be monetary savings. If soft path solutions don't provide the desired outcome, there is still potential for water shortages – with no large-scale supply initiative as a back-up. And, since a number of soft path strategies will require policy guidance and regulations to put in to place, there may be opposition to the idea of adding additional regulatory oversight to existing practices.

It is interesting to note that study respondents voiced almost universal agreement (94.25%) with the statement from the soft path scale "Using recycled or lesser quality water for some tasks can provide valuable cost and energy savings". With San Antonio's extensive use of recycled water, this opinion is provided by individuals with practical experience in the benefits that such a system can offer a city. Such practical experience with one solution recommended by the soft path may ease the transition in San Antonio.

Survey results indicated that a majority of the respondents – all members of state and local water management institutions – held pro-NEP and pro-soft path attitudes, suggesting that acceptance of soft path solutions is possible in San Antonio. Since high scores on the NEP scale were positively correlated with high scores on the soft path scale, providing job candidates with a pre-hire NEP questionnaire could help to target potential employees likely to embrace soft path solutions and help San Antonio further innovate their water management program. NEP surveys distributed to the general public could help to target areas where increased community education can have an impact.

Respondent's education level – Bachelor's degree or above – had a significant impact on responses to the soft path scale. Individuals promoted to management/policy positions are likely to have attained this level of education, providing additional potential to support soft path solutions. Finally, while political ideology was significant with respect to the NEP scale showing a positive relationship between self-identified liberals and higher NEP scores, it did not impact soft path scale results. There is potential, then, that ideology will not prove to be a stumbling block for the implementation of soft path principles.

This study calls attention to the current water management strategies and the potential impacts of applying a soft path paradigm in San Antonio, TX. The implementation of the soft path paradigm in a major city has great potential, and San Antonio could prove to be a valuable case study for future soft path work. To aid in assessing community and institutional support, the results of this study indicate that NEP questionnaire responses can be used to gauge resident's potential level of agreement with soft path principles. Pre-implementation surveys could also show cities where to focus their educational and advertising efforts to increase public awareness and support.

There are, however, some notable limitations to this study. The survey population was chosen from a specific industry rather than the general population, meaning that the results may not generalize to the general public. The number of respondents was relatively small, and they were very similar with regard to educational attainment. While the survey did show a connection between pro-NEP responses and pro-soft path responses, the connection between pro-NEP responses and behavior is tenuous even though it has been demonstrated on occasion.

While not all areas can be managed in exactly the same way, the soft path provides an effective framework for improving our water management strategies and moving toward sustainable water use. By recognizing natural ecosystems as legitimate users of water, the soft path requires solutions that address not just human needs, but the needs of all systems and organisms that depend on that water. Ensuring the health of our natural ecosystems is an important step in providing for our future – and the continued availability of vital ecosystem services. Stagnant policies that simply project future water levels based on current use are overly simplistic, and allow for the status quo to remain instead of encouraging innovation. Setting specific water use goals for a given area – and then working backwards to discern how to achieve them – will provide the framework for change, and an incentive to innovate. Activities that can be accomplished without the use of high-quality or treated water are much more numerous – and use larger volumes of water – than those activities that require such water. Matching water quality to the type of use will enable us to greatly reduce the amount of high-quality water used, while still accomplishing necessary tasks. Finally, a major shift in perspective is needed – we need to change the way we look at water. Focusing on the services that are performed by water (such as keeping our bodies clean), rather than on the water use itself (taking a shower) will allow us to develop new services and technologies to accomplish the same goals with little or no water usage. The application of many of these principles is already underway in San Antonio, TX. Looking at current efforts in this area through a soft path lens and refining the policies already in place can truly make San Antonio into "water's most resourceful city." The soft path is not an easy path, but it holds a great deal of promise for a better water future.

APPENDIX SECTION

APPENDIX A

TEXAS STATE UNIVERSITY
SAN MARCOS
The rising STAR *of Texas*

In future correspondence please refer to 20160808R3937

October 5, 2016

Brooke Bollwahn
Texas State University
601 University Drive.
San Marcos, TX 78666

Dear Ms. Bollwahn:

Your IRB application 20160808R3937 titled "Changing the Way We Look at Water: Applying a Soft Path Approach to Goundwater Management in San Antonio, Tx," was reviewed and approved by the Texas State University IRB. It has been determined that risks to subjects are: (1) minimized and reasonable; and that (2) research procedures are consistent with a sound research design and do not expose the subjects to unnecessary risk. Reviewers determined that: (1) benefits to subjects are considered along with the importance of the topic and that outcomes are reasonable; (2) selection of subjects is equitable; and (3) the purposes of the research and the research setting is amenable to subjects' welfare and producing desired outcomes; that indications of coercion or prejudice are absent, and that participation is clearly voluntary.

1. In addition, the IRB found that you need to orient participants as follows: (1) signed informed consent is not required as participation will imply consent; (2) Provision is made for collecting, using and storing data in a manner that protects the safety and privacy of the subjects and the confidentiality of the data; (3) Appropriate safeguards are included to protect the rights and welfare of the subjects.

This project is therefore approved at the Exempt Review Level

2. Please note that the institution is not responsible for any actions regarding this protocol before approval. If you expand the project at a later date to use other instruments please re-apply. Copies of your request for human subjects review, your application, and this approval, are maintained in the Office of Research Integrity and Compliance. Please report any changes to this approved protocol to this office.

Sincerely,

Monica Gonzales

Monica Gonzales
IRB Regulatory Manager
Office of Research Integrity and Compliance

CC: Dr. Hyun Yun

APPENDIX B

My name is Brooke Bollwahn and I am a graduate student at Texas State University, San Marcos. I have focused much of my study on water policy and water management, and I am using my Thesis project to explore the water soft path and how it might be applied in San Antonio, TX. My project has three major components:

1) Exploring the current water management strategies in San Antonio, TX
2) Correlating ecological beliefs/attitudes with the acceptance of water soft path principles in employees of local water management institutions
3) Presenting an overview of soft path principles, and identifying the potential barriers and opportunities involved in implementing a soft path approach in San Antonio, TX

At this time, I am attempting to survey individuals who work in local/state water management institutions. I have prepared a brief survey with a series of statements designed to assess participant's ecological beliefs/attitudes – and their level of agreement with basic soft path principles. No prior knowledge of the soft path is required to take the survey – participants will simply be asked to indicate their level of agreement with a series of statements.

Please consider taking a few moments to complete the survey linked below. All responses are greatly appreciated!!

Your participation in this research is entirely voluntary. All of your responses are anonymous, and the survey should take approximately 10 minutes to complete. Survey results will be used for the completion of my Thesis project, and will be submitted to a peer reviewed journal.

This study involves no foreseeable serious risks. We ask that you try to answer all questions; however, if there are any items that make you uncomfortable or that you would prefer to skip, please do so.

If you have any questions or concerns feel free to contact Brooke Bollwahn or her faculty advisor, Dr. Hyun Jung Yun:

Brooke Bollwahn, graduate student	**Dr. Hyun Jung Yun, Professor**
Sustainability Studies	**Political Science**
269-214-1876	**512-245-4405**
bjb168@txstate.edu	**hy12@txstate.edu**

This project 20160808R3937 was approved by the Texas State IRB on October 05, 2016. Pertinent questions or concerns about the research, research participants' rights, and/or research-related injuries to participants should be directed to the IRB chair, Dr. Jon Lasser 512-245-3413 – (lasser@txstate.edu) or to Monica Gonzales, IRB Regulatory Manager 512-245-2334 - (meg201@txstate.edu).

If you would prefer not to participate, please do not fill out a survey.

If you consent to participate, please complete the survey.

APPENDIX C

Survey Questions

On a scale from 1 (strongly disagree) to 5 (strongly agree), please indicate how much you agree or disagree with the following statements:

1	2	3	4	5
Strongly Disagree				Strongly Agree

1. We are approaching the limit of the number of people the Earth can support.

2. Humans have the right to modify the natural environment to suit their needs.

3. When humans interfere with nature it often produces disastrous consequences.

4. Human ingenuity will insure that we do NOT make the Earth unlivable.

5. Humans are severely abusing the environment.

6. The Earth has plenty of natural resources if we just learn how to develop them.

7. Plants and animals have as much right as humans to exist.

8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.

9. Despite our special abilities humans are still subject to the laws of nature.

10. The so–called ‘‘ecological crisis’’ facing humankind has been greatly exaggerated.

11. The Earth is like a spaceship with very limited room and resources.

12. Humans were meant to rule over the rest of nature.

13. The balance of nature is very delicate and easily upset.

14. Humans will eventually learn enough about how nature works to be able to control it.

15. If things continue on their present course, we will soon experience a major ecological catastrophe.

16. The natural environment provides us with many important services such as flood control, water purification, and carbon storage.

17. Without major change we are at risk of critically depleting our natural resources.

18. Using recycled or lesser quality water for some tasks can provide valuable cost and energy savings.

19. Future projections based on current data are the best tool for deciding how our resources should be used.

20. The preservation of ecosystem health should be considered when making decisions relating to the use of our natural resources.

21. Natural ecosystems are legitimate users of water.

22. Knowing how to do something is more valuable than understanding why it is being done.

23. Having a specific goal can help initiate a change in behavior.

24. Healthy natural ecosystems are not necessary for humans to flourish.

25. What is your gender? (male; female; prefer not to say)

26. What is your age? (18-25; 26-35; 36-45; 46-55; 56-65; 65 or older; prefer not to say)

27. Would you describe yourself as: (American Indian/Native American; Asian; Black/African American; Hispanic/Latino; White/Caucasian; Pacific Islander; Other; prefer not to say)

28. What is the highest degree or level of education you have completed? (less than high school; high school graduate (includes equivalency); Some college, no degree; Associate's degree; Bachelor's degree; Graduate or professional degree; Doctorate; Prefer not to say)

29. What was your personal income during the past year: (Less than $25,000; $25,000 to $34,999; $35,000 to $49,999; $50,000 to $74,999; $75,000 to $99,999; $100,000 to $149,999; $150,000 to $199,999; $200,000 or more; Prefer not to say)

30. When it comes to politics, do you think of yourself as: (Extremely liberal; liberal; slightly liberal; middle of the road, moderate; slightly conservative; conservative; extremely conservative; prefer not to say)

REFERENCES

Brandes, Oliver M., and David B. Brooks. 2007. "The Soft Path for Water in a Nutshell." *Friends of the Earth Canada, Ottawa, ON and POLIS Project on Ecological Governance, University of Victoria, Victoria, BC.*

Brooks, David B., Oliver M. Brandes, and Stephen Gurman. 2009. "Making the Most of the Water We Have: the Soft Path Approach to Water Management." *Earthscan.*

Burroughs, Suz. 2014. "San Antonio: Be Proud to be a 'Big City, Small Town'." *Rivard Report* (San Antonio, TX), Jan 13, 2014.

Callicott, J. Baird, and Karen Mumford. "Ecological Sustainability as a Conservation Concept." *Conservation Biology* 11, no. 1 (1997): 32-40.

Clark, Christopher F., Matthew J. Kotchen, Michael R. Moore. "Internal and External Influences on Pro-Environmental Behavior: Participation in a Green Electricity Program." *Journal of Environmental Psychology* 23, no. 3 (2003): 237-246.

Clements, Ben. "The sociological and attitudinal bases of environmentally-related beliefs and behaviour in Britain." *Environmental Politics* 21, no. 6 (2012): 901-921.

Corral-Verdugo, Victor. "A Structural Model of Proenvironmental Competency." *Environment and Behavior* 34, no. 4 (2002): 531-549.

Corral-Verdugo, Victor, Robert B. Bechtel, Blanca Fraijo-Sing. "Environmental Beliefs and Water Conservation: An Empirical Study." *Journal of Environmental Psychology* 23, no. 3 (2003): 245-257.

Cortina, Jose. "What Is Coefficient Alpha? An Examination of Theory and Applications." *Journal of Applied Psychology*. 78, no 1 (1993): 98-104.

Curtis, T. "Water infrastructure: The last and next 100 years." *Journal-American Water Works Association* 106, no. 8 (2014): 132-138.

Dreborg, Karl H. "Essence of Backcasting." *Futures* 28, no. 9 (1996): 813-828.

Dunlap, Riley E. "The impact of political orientation on environmental attitudes and actions." *Environment and behavior* 7, no. 4 (1975): 428-454.

Dunlap, Riley E, Kent D. Van Liere, Angela G. Mertig, Robert Emmet Jones. "New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale." *Journal of Social Issues* 56, no. 3 (2000): 425-442.

EAA (Edwards Aquifer Authority). "Groundwater Management Plan." *Edwards Aquifer Authority.* (2010-2015).

EPA (United States Environmental Protection Agency). “Water Efficiency Technology Fact Sheet Composting Toilets.” *Environmental Protection Agency* (1999). Accessed July 24, 2017. (https://www.epa.gov/sites/production/files/2015-06/documents/comp.pdf).

EPA (United States Environmental Protection Agency). “Water Efficiency Technology Fact Sheet Incinerating Toilets.” *Environmental Protection Agency* (1999). Accessed July 24, 2017. (https://www.epa.gov/sites/production/files/2015-06/documents/incinera.pdf).

EPA (United States Environmental Protection Agency). “Water Use Today” *Environmental Protection Agency*. Accessed November 29, 2015. (http://www3.epa.gov/watersense/our_water/water_use_today.html).

Fishbein, Martin, and Icek Ajzen. “Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research.” (1977).

Fitter, Alastair H. "Are ecosystem services replaceable by technology?." *Environmental and Resource Economics* 55, no. 4 (2013): 513-524.

Gleick, Peter, H., Dana Haasz, Christine Henges-Jeck, Veena Srinivasan, Gary Wolff, Katherine Kao Cushing, Amardip Mann. *Waste Not, Want Not: The Potential for Urban Water Conservation in California.* Oakland, CA: Pacific Institute for Studies in Development, Environment, and Security, 2003.

Hermitte, Sam Marie, and Robert E. Mace. 2012. “The Grass is Always Greener…Outdoor Residential Water Use in Texas.” *Texas Water Development Board Technical Note* (2012): 12-01. Accessed July 20, 2017. (http://www.twdb.texas.gov/publications/reports/technical_notes/doc/SeasonalWaterUseReport-final.pdf).

Inskeep, Benjamin, D., and Shahzeen Z. Attari. “The Water Short List: The Most Effective Actions U.S. Households Can Take to Curb Water Use.” *Environment Science and Policy for Sustainable Development* 56, no 4 (2014): 4-15.

Kaiser, Florian, G., Sybille Wolfing, and Urs Fuhrer. “Environmental Attitude and Ecological Behavior.” *Journal of Environmental Psychology* 19, no. 1 (1999): 1-19.

Klineberg, Stephen L., Matthew McKeever, and Bert Rothenbach. “Demographic Predictors of Environmental Concern: It Does Make a Difference How it’s Measured.” *Social Science Quarterly* 79, no. 4 (1998): 734-753.

Liu, Lee “Sustainability: Living within One’s Own Ecological Means.” *Sustainability* 1, no. 4 (2009): 1412-1430.

Liu, Xinsheng, Arnold Vedlitz, and Liu Shi. "Examining the determinants of public environmental concern: Evidence from national public surveys." *Environmental Science & Policy* 39 (2014): 77-94.

Lopez, Antonio Gonzalez, and Maria Amerigo Cuervo-Arango. "Relationship Among Values, Beliefs, Norms and Ecological Behavior." *Psicothema* 20, no. 4 (2008): 623-629.

Maupin, Molly A., Joan F. Kenny, Susan S. Hutson, John K. Lovelace, Nancy L. Barber, and Kristin S. Linsey. *Estimated Use of Water in the United States in 2010.* No. 1405. United States Geological Survey, 2014. Accessed December 6, 2015. (pubs.usgs.gov>circ>pdf>circ1405).

Mayer, Peter W., William B. DeOreo, Eva M. Opitz, Jack C. Kiefer, William Y. Davis, Benedykt Dziegielewski, and John Olaf Nelson. "Residential End Uses of Water". (1999). Accessed December 9, 2015, (http://www.waterrf.org/publicreportlibrary/rfr90781_1999_241a.pdf).

McAlpine, Clive A., Leonie M. Seabrook, Justin G. Ryan, Brian J. Feeney, William J. Ripple, Anne H. Ehrlich, and Paul R. Ehrlich. "Transformational change: creating a safe operating space for humanity." *Ecology and Society* 20, no. 1 (2015).

Metro Vancouver "Ecological Services". *Metrovancouver.* Accessed August 23, 2017. (http://www.metrovancouver.org/services/regional-planning/conserving-connecting/about-ecological-health/ecological-services/Pages/default.aspx.).

Mohai, Paul, and Ben W. Twight. "Age and environmentalism: an elaboration of the Buttel model using national survey evidence." *Social Science Quarterly* 68, no. 4 (1987): 798-815.

Nasr, Susan L. "How Waterless Toilets Work". (2009). Accessed November 29, 2015. (http://www.science.howstuffworks.com/environmental/green-tech/sustainable/waterless-toilet.htm).

Nilsson, Andreas, Andre Hansla, Joakim Malmborg Heiling, Cecilia Jakobsson Bergstad, Johan Martinsson. "Public Acceptability Towards Environmental Policy Measures: Value-Matching Appeals." *Environmental Science and Policy* 61 (2016): 176-184.

Nunnally, Jum C. "Psychometric theory." (1967).

Pachauri, Rajendra K., Myles R. Allen, Vicente R. Barros, John Broome, Wolfgang Cramer, Renate Christ, John A. Church et al. *Climate change 2014: synthesis Report. Contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change*. IPCC, 2014.

Public Utility Commission of Texas. "Water Supply Corporations: Frequently Asked Questions." *Utili-Facts.* Accessed December 9, 2015. (https://www.puc.texas.gov/consumer/facts/factsheets/waterfacts/WaterSupplyFAQ.pdf).

SAWS (San Antonio Water System). "2012 Water Management Plan". *San Antonio Water System*, (2012). Accessed December 9, 2015. (http://www.saws.org/Your_Water/WaterResources/2012_WMP/docs/20121204_2012WMP_BoardApproved.pdf).

SAWS (San Antonio Water System). "Water Management Plan Semiannual Report January-June 2016" *San Antonio Water System*, (2016). Accessed February 23, 2017. (http://www.saws.org/Your_Water/WaterResources/2012_WMP/docs/WaterMgmtSemiannualReport_Jan-June%202015_final.pdf).

SAWS (San Antonio Water System). Accessed November 30, 2015. (http://www.saws.org).

SAWS (San Antonio Water System). Accessed March 3, 2017. (http://www.saws.org).

S.B. No 1477. *Edwards Aquifer Authority Act.* Accessed December 7, 2015. (file:///C:/Users/bstotler/Downloads/EAA%20Act.pdf).

Series, Millennium Ecosystem Assessment. "Ecosystems and Human Well-being: A Framework for Assessment. 212p." (2003). Accessed November 25, 2015. (http://pdf.wri.org/ecosystems_human_wellbeing.pdf).

Simon, Julian L. "Can the Supply of Natural Resources Really Be Infinite? Yes!." *The Ultimate Resource* 2 (1996).

Tavakok, Mohsen and Reg Dennick. "Making sense of Cronbach's alpha" *International Journal of Medical Education* 2 (2011): 53-55.

Teproff, Carli. "New homes will now require solar panels in South Miami, a first in Florida." *Miami Herald.* (Miami, FL), July 18, 2017.

Texas Administrative Code. *Title 30. Environmental Quality.* Part 10. Chapter 281. Subchapter A. Accessed October 5, 2017. (https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=281&rl=4).

Texas Administrative Code. *Title 31. Natural Resources and Conservation*. Part 10. Chapter 356. Subchapter A. Accessed November 24, 2015. (http://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=2&ti=31).

Texas Beyond History. *Lower Pecos Canyonlands. Before Amistad.* (2008). Accessed July 18, 2017. (https://www.texasbeyondhistory.net/pecos/before.html).

Texas Health and Safety Code. *Chapter 341. Minimum Standards of Sanitation and Health Protection Measures.* Subchapter A. Accessed November 30, 2015. (http://www.statutes.legis.state.tx.us/Docs/HS/htm/HS.341.htm).

Texas Rainwater Harvesting Evaluation Committee. *Rainwater Harvesting Potential and Guidelines for Texas.* (2006). Accessed July 11, 2017. (http://www.twdb.texas.gov/innovativewater/rainwater/doc/RainwaterCommitteeFinalReport.pdf?d=3757.2900000000004).

Texas Tax Code. *Chapter 151. Limited Sales, Excise, and Use Tax*. Subchapter A. Accessed March 16, 2017. (http://www.statutes.legis.state.tx.us/Docs/TX/htm/TX.151.htm).

Texas Water Code. *Chapter 11 Water Rights*. Accessed November 24, 2015. (http://www.statutes.legis.state.tx.us/Docs/WA/htm/WA.11.htm).

TWDB (Texas Water Development Board). “2016 Regional Water Plan – Municipal Water Demand Projections for 2020-2070 City Summary (San Antonio)” *Texas Water Development Board,* (2017). Accessed February 24, 2017. (http://www2.twdb.texas.gov/ReportServerExt/Pages/ReportViewer.aspx?%2fProjections%2f5-demand_city&rs:Command=Render).

TWDB (Texas Water Development Board). “2016 Regional Water Plan – Population Projections for 2020-2070 City Summary (San Antonio)”. *Texas Water Development Board,* (2017). Accessed February 24, 2017. (http://www2.twdb.texas.gov/ReportServerExt/Pages/ReportViewer.aspx?%2fProjections%2fpop_City&rs:Command=Render).

TWDB (Texas Water Development Board). ”2017 Texas State Water Plan” *Texas Water Development Board,* (2017). Accessed March 14, 2017. (https://2017.texasstatewaterplan.org/entity/126).

TWDB (Texas Water Development Board). “Desired Future Conditions, GMA 1” *Texas Water Development Board,* (2009). Accessed November 24, 2015. (http://www.twdb.texas.gov/groundwater/docs/DFC/GMA1_DFC_Adopted_2009-0707.pdf).

TWDB (Texas Water Development Board). “Desired Future Conditions, GMA 10.” *Texas Water Development Board,* (2010). Accessed November 24, 2015. (http://www.twdb.texas.gov/groundwater/docs/DFC/GMA10_DFC_Adopted_2010-0804.pdf).

The Center for Land Use Interpretation. “Immersed Remains: Towns Submerged in America.” *Lay of the Land Newsletter*, (2005). Accessed November 23, 2015. (http://www.clui.org/newsletter/spring-2005/immersed-remains-towns-submerged-america).

Thompson, Suzanne C. Gagnon, Michelle A. Barton. "Ecocentric and Anthropocentric Attitudes Toward the Environment" *Journal of Environmental Psychology* 14, no. 2 (1994): 149-157.

United Nations Department of Economic and Social Affairs. "World Population Projected to Reach 9.7 Billion by 2050." *United Nations Department of Economic and Social Affairs,* (2015). Accessed November 30, 2015. (https://www.un.org/development/desa/en/news/population/2015-report.html).

Uyeki, Eugene S., and Lani J. Holland. "Diffusion of pro-environment attitudes?." *American Behavioral Scientist* 43, no. 4 (2000): 646-662.

Watkins, Kevin. "Beyond scarcity: power, poverty and the global water crisis." *Human Development Report* 11, (2006). Accessed November 24, 2015. (http://hdr.undp.org/sites/default/files/reports/267/hdr06-complete.pdf).

Wolters, Erika Allen. "Attitude-Behavior Consistency in Household Water Consumption." *The Social Science Journal* 51, no. 3 (2014): 455-463.

Yu, Zita LT, J. R. DeShazo, Michael K. Stenson, and Yoram Cohen. "Cost-benefit analysis of onsite residential graywater recycling—A case study: The City of Los Angeles." *Journal – American Water Works Association* 107, no. 9 (2015) E436-E444.