AN ABSTRACT OF THE THESIS OF

Nicholas Christopher Kusanto for the degree of Honors Baccalaureate of Science in Chemical Engineering presented on June 3rd, 2014. Title: Sustainable US Federal Water Policy Recommendations.

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Climate change, population growth, aging infrastructure, poor water management, and aquifer depletion are reducing US water supply. Increasing water scarcity will lead to an inability to support agriculture, industry, energy, and municipal demand that will negatively affect US economic growth and national security. Traditional water policy measures of expanding supply through infrastructure are no longer feasible in the face of $384 billion of infrastructure repair in the next 30 years. This report will explore alternative policy recommendations for the Federal government that will lead to more sustainable and robust water systems across the US.

Key Words: water, policy, sustainability, reuse, greywater

Sustainable US Federal Water Policy Recommendations

By

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

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Introduction

Less than 1% of the world's water is available as fresh water[1] for human consumption. Facing a global population growth rate of one percent and an increase in world temperatures by two to three degrees Celsius in the next 30 years, demand for water will increase by 40 percent and leave "nearly half of the world's population" in situations of severe water stress[2] by 2030 (National Intelligence Council (NIC), 2012). The unavailability of clean fresh water will lead to human health issues, economic vulnerability, and food shortages around the world. The US is facing dire problems; water is pumped from the Ogallala aquifer "eight times faster than it is replenished while dramatic drops in water levels at Hoover Dam, Lake Mead and Lake Powell [have resulted in] adverse effects on local economies" (Singh, 2008). The economic effects of a lack of renewable fresh water have forced Nevada's farmers to forgo early planting and New Mexico's ranchers to sell cattle because traditional water reservoirs have dried up (Nagourney, 2014). If the US wants to avoid the negative effects water scarcity can have on industry, agriculture, the environment, and municipalities, effective water management techniques must be implemented now.

The US has historically treated water as an unlimited resource. The majority of US water bills reflect the cost of water transportation and treatment, but water, itself, is free. As a result of inexpensive water prices and perceived widespread availability, the "average family of four uses 400 gallons of water per day" compared to the "5 gallons of water the average African family uses in a day" (Environmental Protection Agency

[1] Fresh water: potable water available for drinking and other applications
[2] Water stress: demand for water exceeds amount available during a certain time period; poor water quality affects usage (EEA, 2013)

(EPA), 2013c). Clearly, lack of water will more drastically affect US quality of life in comparison to areas in the world that already survive on less. From 1900 to 2000, the United States Census Bureau recorded a population "increase of 240 percent" (National Research Council (NRC), 2012). Figure 1 illustrates projected population growth from 1970 to 2030. Population growth is highest in the Southwest and Southeast; two areas that face immense water crisis issues due to climate change, increasing demand, and depleting resources. Development of more water efficient technologies and major water infrastructure projects, such as dams, enabled the US to meet growing water demands during the mid-20th century. While US water consumption – both total and per capita usage – has decreased for the past 30 years, continued groundwater consumption will also decrease America's ability to rely on its aquifers. For example, more than 195 million acre-ft of water have been removed from the 111 thousand acre Ogallala (High Plains) aquifer in the 20th century—"a reduction of about 6% of predevelopment volume in storage," leading to higher pumping costs and decreased energy use efficiencies (McGuire, 2003). Thus, climate change, rapid depletion of US aquifers, and the decline water supply infrastructure construction requires that more comprehensive measures be taken to ensure "swimmable and fishable" waters for generations to come (Clean Water Act, 1972).

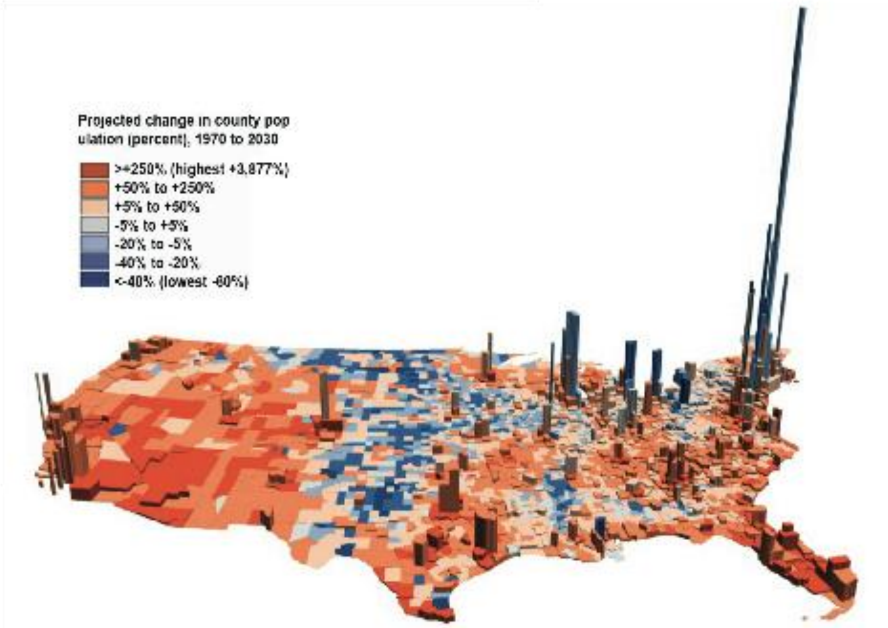

Figure 1. Map of US Projected Population Growth, 1970 to 2030
Source: www.usgcrp.gov

Water reuse technology is one method for addressing the nation's water crisis. Data compiled in the National Research Council's *Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater* reported that 12 out of 32 billion gallons per day (BGD) of municipally treated wastewater is discharged into the ocean (NRC, 2012). By reusing treated wastewater in coastal cities, especially in the Southwest corner of the US, the nation's water supply would increase by six percent nationwide and 27 percent for the public water supply[3]. Increased water reuse has the potential to limit dependence on sensitive water systems and reduce energy costs that correspond to water treatment. Reclaimed water[4] can benefit a variety of industries, which include: food crop irrigation, industrial cooling, wetland restoration, groundwater

[3] Public water supply: refers to water specifically withdrawn and delivered to domestic, commercial, and industrial users. Water is provided to a minimum of 25 people or 15 connections (US Geological Survey (USGS), 2014).
[4] Reclaimed water: water that has been chemically or naturally treated by a waste water treatment facility. The term can be used synonymously with recycled water (EPA, 2013b)

recharge, and toilet flushing, among others. While the benefits of water reuse technologies seem clear, slow implementation of these techniques may lead to widespread water unavailability and inflated water costs across the US.

Lack of foresight and negative public opinion has limited the widespread use of water reuse technologies. The majority of water infrastructure was built at least five decades ago, a time when optimistic water estimates did not foresee a decline in water availability. However, time, research, climate change, population growth, energy development and use, and droughts have proven otherwise. The combination of increasing water withdrawals and an aging water infrastructure has contributed to recent concerns regarding the stability of the current national water system. It is predicted that from 2011 to 2030, the costs for repairs of the US water infrastructure will exceed $384 billion (EPA, 2009). In addition, the cost to implement water reuse technology and repair the current infrastructure will cost municipalities and state governments billions of dollars unless a method for combining the two systems can be found. However, public distaste for water reuse has and will continue to prevent water reuse policy and regulation if government fails to fund water research, educate the public, and create robust infrastructure. While people "generally favor reuse that promotes water conservation [and] protects human health...as the water options become more tangible to people with specific proposed projects in their communities...the public's support wanes" (Troy, 2006). This phenomena, known as the "yuck factor", has prevented municipalities and governments from effectively implementing water reuse systems as a means to addressing water availability issues.

Another means to increase the nation's water supply is by implementing greywater[5] systems in residential housing, public buildings, and in inner cities. Greywater differs from reclaimed water because the wastewater is not treated up to drinking level standards and is most commonly used for either flushing toilets or watering yards. At individual use sites, greywater can account "for as much as 50% of the indoor potable water use and [meet] about half of the demand for outdoor irrigation" (Sheikh, 2010). Greywater systems may lead to annual water savings, decrease in energy usage, and prove useful in drought periods, especially in California and Arizona. Decreased public demand will slightly increase water available for irrigation and industry, but have a larger effect on individual management and policy. However, like reclaimed water, greywater systems are not common the US.

This report will identify how the Federal government can incentivize the movement for State and local governments to encourage and implement water reuse technologies and better policy. The effects of federal standardization of water will be discussed and a best course of action will be recommended. Novel technologies for wastewater reuse will be evaluated and presented as part of a nationwide initiative. Behavioral economics will be explored as an option to encourage public adoption of water reuse infrastructure in communities, parks, and buildings. In addition, effective national greywater measures will be suggested as another means for Americans to reuse water. An examination of ways government and private sector can cooperate to implement these technologies will be addressed and encouraged.

[5]Greywater: wastewater with microbial concentrations far in excess of levels established in drinking, bathing, and irrigation water standards for recycled water. Greywater includes but is not limited to wastewater from baths, showers, bathroom sinks, and washing machines. In some cases, greywater is collected from kitchen sinks (Sheikh, 2010).

Background

Fresh water serves as the basis for all human activity. Water is necessary in a variety of applications that range from the generation of hydroelectric power to crop irrigation using the nation's aquifers and surface waters. As such, ensuring access to water has been very important in the historical expansion and growth of the US. Today, the nation withdraws[6] 410 BGD to satisfy municipal, agricultural, and industrial needs, 80% of which is supplied by surface waters (Kenny, 2005). The nation's level of water use, coupled with increasing temperatures, has led to aquifer depletion and fear of water unavailability, especially in drier western states. For example, the current drought in the winter of 2013-2014 has led to a historic low snowpack in California's Sierra Nevada, 29% below the average (Bureau of Reclamation, 2014). As a result, agricultural water service providers in California's Central Valley Project are allocated 0 to 50% of their contracted supply, which means that farmers might not receive necessary flows of water to irrigate their fields. In turn, food production will decrease, resulting in increased produce prices that will affect the entire economy. It is important to improve water infrastructure and security to accommodate for population growth, shrinking water supply, and climate change.

Over time, it became apparent that the human system must respect the ecosystems that source water. Civilian deaths and sicknesses caused by heavy industrial pollution in the 1960's convinced American lawmakers that protection of the environment is essential to protecting American health. As a result, the 1972 Clean Water Act (CWA) and the

[6] Water withdrawal refers to water that is recycled back into rivers and reservoirs and not consumed.

1974 Safe Drinking Water Act (SDWA) solidified US commitment to the environment and people. The CWA gave power to the Environmental Protection Agency (EPA) to govern water pollution, eliminating and regulating the amount of toxins released into the environment. The SDWA was enacted to ensure that water infrastructure and treatment facilities provide safe drinking water for the public. Both of these acts were made to benefit and protect both human and environmental systems. Since then, decisions regarding water quality regulations have weighed the effects on human health and the environment.

Water Demand

The availability of US water is a function of supply and demand. On the demand side, variables such as population, ecosystems, industry, and agriculture withdraw and consume water. Fortunately, since 1985, despite a "US population growth rate [of] 0.9%...US water use has been stable at approximately 210 BGD (excluding thermoelectric)" due to advancements in water use efficiency (National Research Council, 2012). Agriculture, in particular, accounts for "approximately 80 percent of the nation's consumptive[7] water use" and up to 90% in Western States (United States Department of Agriculture, 2013). Continued growth in population, agriculture, municipalities, and industry will further increase demand to a point where water efficiency will not be enough. For instance, climate factors and poor policy regulation have forced water authorities to reduce Lake Powell and Lake Mead reservoir flows by 750,000 acre-ft to the Colorado River—a water source that supplies water for 40 million people and irrigates 4 million acres of farmland ranging from California to Wyoming

[7] Water consumption is water which is lost and not replenished. For instance, water used for agriculture is consumed because plants use water that has infiltrated through their roots, preventing water from being stored as groundwater supply.

(Weaver, 2014). In addition, expected population growth in California of 6 million people by mid-century will put further strains on a system that does not have enough water to go around (Weaver, 2014).

The combination of decreased water flows and increased population will reduce available water supply for all users. Increased consumption will further strain the nation's resources, environmental wellbeing, and water infrastructure that transport the nation's water supply. The implementation of small and large scale water reuse technologies or even clearer water re/use policies may be able to reduce the strain that 410 BGD of moving water exerts on the nation's aging water infrastructure.

Water Supply

The nation's water supply is a function of the water cycle. Water cycles vary across the US. In the west, water is abundant in wet winters and less so in dry summers: characteristics of a Mediterranean climate. On the other hand, to the east of the Mediterranean climate, areas such as Eastern Arizona, New Mexico, and West Texas experience two rainy seasons: "frontal winter storms and summer thunderstorms" (Leopold, 1997).

The water supply is replenished by precipitation that falls onto the earth and moves through infiltration into the ground, runoff, or evapotranspiration. These water movements supply surface water and groundwater, which are then used by people and surrounding ecosystems. Surface water encompasses water located above ground, including ice caps, glaciers, rivers, lakes, wetlands, the atmosphere, and oceans. These systems are replenished through precipitation and when groundwater discharges into the surface. Evaporation, humans, transpiration, and ecosystems consume surface water.

Increased temperatures reduce water supply by increasing evaporation of water held in rivers, lakes, and reservoirs. In particular, communities that rely on glacier or snowpack storage for water in drier months are in the most danger of water shortages. Snowpack in the Northwestern region of the US, such as Oregon, are particularly susceptible to increased temperatures that melt frozen water storages before they are most needed in the drier months of the summer. These water storages end up flowing into the ocean before they can be used to irrigate fields and in industry. Increased water storage through implementation of aquifer recharge technology or dams can be used in the winter months to harvest runoff water for the drier season. However, these solutions have policy implications and environmental regulations that affect their feasibility. Surface waters move much quicker in its cycle than groundwater. Unlike groundwater, national concern regarding surface water stresses when water might be available rather than depletion of stored water, often found to be thousands of years old by water dating techniques.

On the other hand, groundwater refers to water that is stored beneath the ground in the spaces between solid particles. According to the US Geological Survey (USGS), groundwater withdrawal accounts for 20% of the nation's daily withdrawals, about 82.6 BGD (USGS, 2005). While surface waters display short cycling times, groundwater water cycles are typically much longer. For example, the water withdrawn from the 111 thousand acre Ogallala aquifer that provides for the majority of agriculture in Texas, New Mexico, Oklahoma, Colorado, Wyoming, Nebraska, and South Dakota dates back to the last ice age (Department of the Interior, 2012). The nation is withdrawing water from its aquifers at a rate faster than they are able to naturally recharge. Water withdrawals from the Ogallala aquifer have increased the average depth from the land surface to the water table[8] from 80 to 240 feet today. According to former USGS director, Marcia McNutt, "in less than 100 years we are seriously depleting what took nature more than 10,000 years to fill" (Department of the Interior, 2012). A simple mass balance of the water in and water out displays a negative water balance where consumption exceeds recharge, leading to a decrease in storage, supply and increased costs to extract. From 1978 to 1984 alone, annual pumping costs for individual farms reached $7,800 or more, eliminating 370 acres of farmland because water-pumping costs were too high (Leopold, 1997). In addition, it has been reported that the maximum rate of withdrawals from a farmer's well on the Ogallala aquifer sank from 1600 gallons per minute in 1964 to 195 gallons per minute today, illustrating how it is becoming increasingly more difficult to withdraw (Wines, 2013). Figure 2 displays the depletion of US groundwater in select basins from 1970 to 2008.

[8] Water Table: Upper surface of groundwater below which rock or sediment is saturated with water that fills all voids

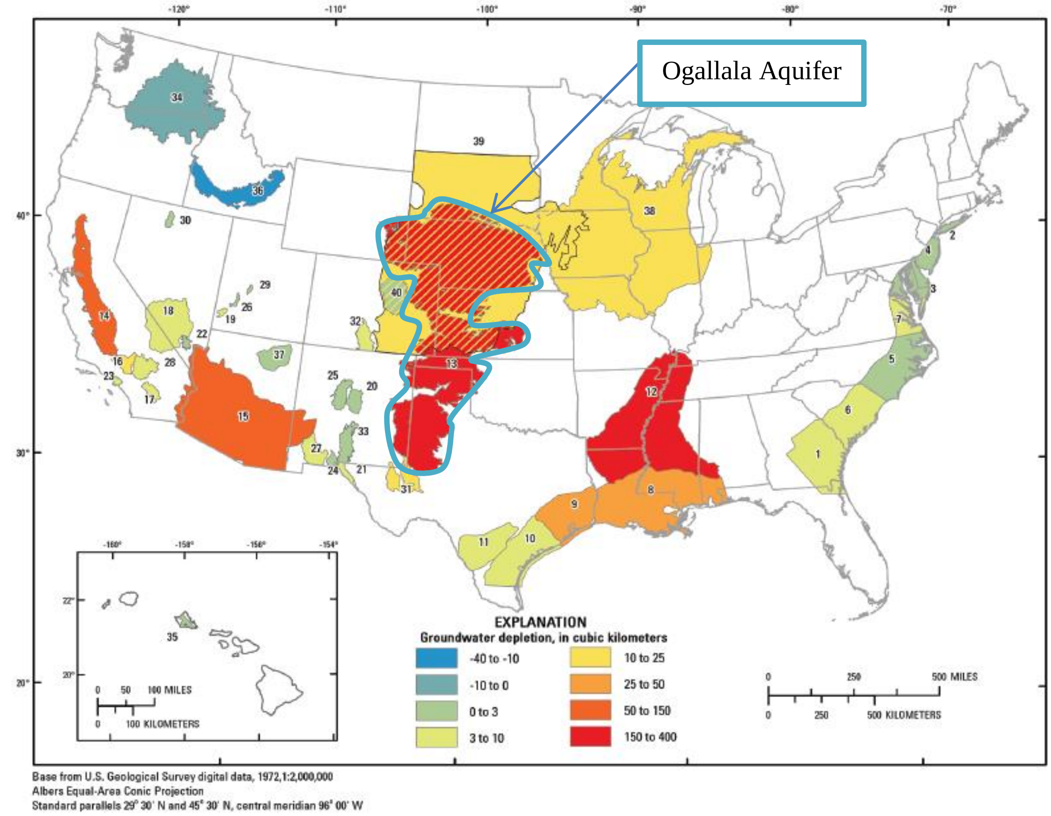

Figure 2. Map depicting Groundwater Depletion since 1970
Source: (USGS, 2005)

Depletion of the nation's aquifers will prevent a high percentage of the agricultural sector from producing crops that feed both the nation and the world. No amount of efficient water use will protect the nation's aquifers from depletion because consumption will continue to outpace slow recharge as growing populations require more energy, food, and water. Areas in California and Arizona have been forced to ration water supplies and impose planting and water restrictions to reduce water usage. It is important to conserve, recharge, and reuse the nation's water supplies so that future generations can continue to prosper from US economic growth. Large aquifer withdrawals with non-renewable recharge will increase energy costs to pump water from lower depths and lead to a variety of environmental problems that include saltwater intrusion and land subsidence.

It has been shown that salinity levels in aquifer waters lead to 50 percent product loss of agricultural crops (Steppuhn, 2005). Thus, as saltwater penetrates into the aquifer supply, US citizens will experience increased water treatment costs to desalinate water for both public and agricultural use, which cannot be ignored. Areas in Southern California and Southeast Florida have resorted to injection wells that pump water into its aquifers to prevent saltwater intrusion. It is important to manage these systems effectively to ensure sufficient fresh water for generations to come before high water costs prevent economic growth and safe drinking water conditions.

The nation has attempted to reduce water consumption by increasing water supply and developing more efficient water use technology. The bulk of water supply infrastructure was built in the early and middle 20th century, at least 5 decades ago. Some systems are much older, for instance, New York still transports water in some pipes made from hollowed logs. Surface waters in the Southwest, particularly rivers, were dammed to generate power and provide water for “rapid population growth and increases in irrigated agriculture” (NRC, 2012). Today, construction of water supply infrastructure has declined due to: “(1) a diminishing number of rivers whose flow is not already claimed by other users, (2) increased concern about adverse impacts of impoundments on stream ecology, and (3) a better understanding of water quality problems caused by irrigated agriculture” (NRC, 2012).

Water Use Efficiency

As a result, increased water efficiency was used as a means to better address limited supply. Improvements to water efficiency can be accomplished by a number of ways that address the supply and demand side. On the supply side, utilities and government agencies provide infrastructure to transport water to users. Utilities have reduced water loss in pipes by placing water meters in pipes in an attempt to locate areas needing repair. However, more needs to be done. It is reported that on average, 14 percent of treated water is lost in leaks, with some areas reporting losses of 60% (EPA, 2009). Simplifying the US water balance and integrating this percentage with the 410 BGD withdrawals illustrates that roughly 60 BGD of treated water is lost to leaky pipes. These inefficiencies in the water delivery system waste energy, time, and funding to treat and transport the water supply. According to a report by the National Resources Defense Council, approximately 90% of farmers' electricity use is pumping groundwater (Cohen, 2004). The combination of 60,000 water systems and 15,000 wastewater systems require 75 billion kWH/year, roughly 3% of US annual energy consumption (Cohen, 2004).

Thus, a significant amount of energy and resources are spent and wasted on distributing water to private and public entities. On the demand side, development of consumer efficient products and a tiered rate structure for water usage has been used to reduce consumption and withdrawal. However, more must be done to control the nation's water consumption. Incentives to buy and produce water efficient products such as Watersense low flow showerheads and water efficient toilets can reduce water usage in homes. Tiered water rates can affect consumption by rewarding low use and increasing water costs based on increased usage. A few counties in water stressed areas such as

Arizona and California have already adopted these policies to address their water shortages. Widespread adoption of these policies may lead to increased State and Federal funding for water infrastructure repair or renewal to meet the needs of growing populations and industries. However, current increases in water efficiency may not sufficiently address US water problems. Figure 3 forecasts the condition of water in the US in 2050.

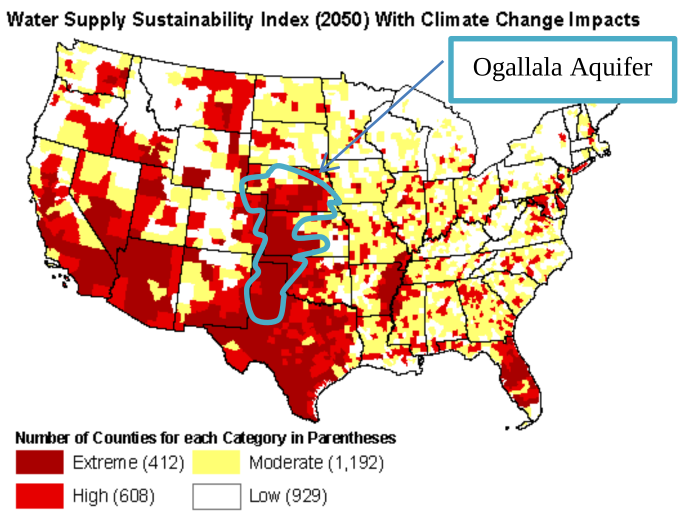

Figure 3. Map of US Water Supply Sustainability
Source: (Natural Resources Defense Council, 2010)

If these trends continue, water scarcity will lead to higher water prices with inadequate pricing structures that do not support future infrastructure, ultimately affecting the public. Thus, the effects fresh water availability has on economies, societies, and environments cannot be ignored. Rather, adoption of wiser water management practices is needed to ensure a productive and stable nation.

Water Reuse

Thus, it is important to explore water reuse as one of many options to renew our nation's water supply. Currently, it is estimated that "reusing wastewater effluent to provide water for industry, irrigation, and potable supply...accounts for a small part (<1 percent) of US water use" (NRC, 2012). Clearly, water reuse has potential for exponential growth in the nation's water infrastructure. Encouraging industry, especially high water users, to limit water consumption will reduce demand on fresh water and energy required to transport influent and effluent to and from facilities. For example, "in 1995, in Panhandle and the South Plains of Texas, almost 5.48 billion gallons of water was conserved by reusing waste water for power plant cooling." (Asano, 2011). Reclaimed non-potable water—otherwise known as greywater which is unfit for human consumption—can be used to water golf fields, lawns, in agriculture and landscapes. Due to advanced water treatment technologies, recharging aquifers with reclaimed water can replenish and prevent overconsumption, land subsidence, and saltwater intrusion of the nation's groundwater supplies. Through water reuse and sustainable policy in both reclaimed potable water or greywater systems, the nation can act as stewards of the environment, decrease diversion of freshwater from sensitive ecosystems, and fill the water needs of growing populations and emerging economies.

Policy Background

Water Rights

In the US, a water right is a property right[9] and individual states regulate water allocations as opposed to the Federal government. Conversely, the Federal government develops national water quality standards with the individual states opting to manage through state agencies. Accordingly, each State differs in its management of specific

[9] Property Right: A person who owns a certain piece of property has the right to the resources on the land.

water systems. The primary methods for distributing water rights are primarily divided into two categories: riparian and prior appropriation. Some states use a combination of the two doctrines of water appropriation. Water reuse law and regulation must work within each of these systems without undermining water rights.

Riparian rights originated in English common law and predominate in many Eastern States where access to water was not a major concern to early settlers. According to riparian law, only those who own property adjacent to water may use the resource in its natural condition[10]. A more modern interpretation of the law allows for 'reasonable use' that does not cause unreasonable injury to another riparian user, which means that water can be used as long as downstream flow and quality are not affected. These policies can come into conflict with implementation of greywater systems because withdrawn water is not flushed back into pipes for downstream treatment but is consumed for irrigation, thereby possibly lowering downstream flow.

Prior appropriation originated as peopled moved West and water became scarcer, and is used in States such as California, Nevada, and Arizona. Water rights are given based on seniority of land ownership, and are based on the *first in time, first in right* principle. Water right owners must demonstrate that they are exercising their water rights to improve the land. Unlike riparian rights, users can lose their water rights if they do not display purposeful use of their water rights under the prior appropriation doctrine; *use it or lose it*. The doctrine discourages users from reducing water consumption because failure to prove purposeful use of their water rights may lead to reduction in their annual allotments.

[10] Natural Condition: The water resource has not been augmented in any way other than to withdraw for use. Augmentation includes stream diversion, anything which affects the speed of the stream, etc.

Water Legislation

Historically, water legislation has neglected water reuse. The last large pieces of legislation were passed by congress in the early 1970s, which includes the Clean Water Act (CWA) of 1972 and the Safe Drinking Water Act (SDWA) of 1974. The CWA is the largest piece of water regulation that governs water pollution by setting acceptable limits of chemical concentrations in US water supply, excluding groundwater. This piece of legislation calls for fishable and swimmable surface waters in the US. The CWA originally provided grants and funding to assist publicly owned treatment works (POTW), but was replaced by the Clean Water State Revolving Fund (CWSRF) through amendments in the Water Quality Act of 1987. The CWSRF has provided over $100 billion in assistance for water quality projects, 96% of CWSRF funding has gone to wastewater treatment projects (EPA, 2014). The SDWA ensures that all Americans have access to clean drinking water. The SDWA has since been amended in 1986 and 1996 to widen regulation to continue to protect rivers, lakes, reservoirs, springs and wells. In both cases, the EPA sets the standards, which are then overseen by State governments. Funding for these water protection programs is typically split between the State and Federal governments, 65 and 35 percent, respectively; however, states have the option of deferring primacy to the EPA. These pieces of legislation were created at a time when water was seen as an abundant resource and there was no need for water reuse. However, growing population and water demands have contributed to the rise of a gamut of methods to treat and generate water, which include: wastewater treatment facilities and water desalination plants. Primary funding for drinking water infrastructure and maintenance is provided by the Drinking Water State Revolving Loan Fund (DWSRF), which was created by the 1996 amendments to the SDWA. Federal money given to the EPA is distributed to States, Tribes and territories to “install, improve or maintain treatment facilities” (EPA, 2013a). The total forecasted budget for FY 2014 is $817 million (EPA, 2013a).

In May of 2013, Senate unanimously passed the Water Resources and Development Act of 2013, S. 601, to improve water infrastructure and supply. It will also give authorization to the Secretary of the Army to construct improvements to rivers and harbors in the US. Importantly, in Sec. 10007.titled Projects Eligible For Assistance, lines 15 to 17, “a brackish or sea water desalination project, a managed aquifer recharge project, or a water recycling project” is eligible to receive Federal assistance. In response, Representative Shuster of Pennsylvania led the initiative in the House of Representatives on H.R. 3080—Water Resources Reform and Development Act of 2013. The bill has since been passed by congress by a vote of 412 to 4 in May 2014. The following titles provide a brief overview of the potential impacts H.R. 3080 might have on US water infrastructure (VoteTocracy, 2013):

1. Title 1 directs the Army Corps of Engineers to start a pilot program to develop 15 water infrastructure projects to improve coastal harbors, reduce flooding and hurricane damage, and restore ecosystems. The Corps is also responsible to develop levee safety guidelines and manage water studies and projects.
2. Title 2 improves U.S. ports and waterways.
3. Title 3 eliminates $12 billion worth of projects to free funding for other ventures

4. Title 4 authorizes the Corps to develop 23 new projects to support US navigation systems, improve flood management, and protect the environment.

According to the Congressional Budget Office—CBO, the "bill would cost about $3.5 billion from 2014-2018, and then another $4.7 billion from 2019-2023" (VoteTocracy, 2013). While the bill does not address all water-related problems or attempt to standardize safety regulations for varying types of reclaimed water, it acts as a good start to attempt to fund sustainable projects that consciously use water resources.

Water Research Agencies

The US has three major organizations that conduct water reuse research. The three include the WateReuse Association, the Water Research Foundation, and Water Environment Research Foundation (WERF). The mission of the WateReuse Association is to "advance the beneficial and efficient uses of high-quality, locally produced, sustainable water sources for the betterment of society and the environment through advocacy, education and outreach, research, and membership." The Water Research Foundation focuses on drinking water by addressing infrastructure, management and customer relations, water quality, and water resources and environmental sustainability. The WERF narrows its research to wastewater and storm water. Many State governments take the recommendations and expertise offered by these organizations when developing their own schemes to address water infrastructure and management.

Key Conflicts

Decentralization of Water Regulation

While water reuse provides one of many alternatives to improving water systems, the decentralization of water quality regulation and rights prevents a single solution. Treatment regimens for non-potable or potable situations must follow distinct regulations regarding surface and groundwater treatment in each State. Fit to purpose[11] treatment schemes vary within different States based on the application such as irrigation, toilet flushing, drinking water, etc. State governments have ignored the guidelines proposed by the EPA for water reuse and management, furthering complicating the issue. Even then, if States adopt EPA guidelines, they are also free to raise or reduce standards to their choosing.

Separation between the Public and Water Supplies and Treatment

The public lacks an understanding of the costs associated with water infrastructure and treatment. Unlike roads and building, water infrastructure is hidden underground and treatment facilities are located in less urban areas, contributing to an "out of sight, out of mind" mentality. Because water is out of sight, it is difficult for the public to understand proposals to increase funding for agencies such as the EPA. Likewise, lack of government initiative to publicize and promote water sustainability further prevents public conversation on wiser water management, failing to encourage and incentivize water reuse. The White House is concerned with the following issues such as civil rights, energy, immigration, health care, and technology, while a single issue is not devoted to water. Because there is a lack of Federal government initiative, the

[11] Fit-to-purpose: Treating water to a level which fits the needs of the application.

public has not been given the resources to be aware of how water problems in California—a state responsible for 11.3 percent of US total agriculture—might affect the food prices they see in their marketplaces (California Department of Food and Agriculture, 2013). The uninformed public has not been given the tools to understand how water rates are subsidized, and why states must change their water pricing structures to encourage sustainable growth. At the same time, it is important to acknowledge the realities of a political climate that is not open to raising taxes or suggest increased funding water projects, especially if nothing is broken. As the country attempts to address the $384 billion required for infrastructure repair, it seems unlikely that the public or government officials would like to suggest extra funding for water reuse infrastructure (EPA, 2009). Incentivizing the integration of water reuse technology in the private development sector and existing infrastructure will be the most cost effective platforms for wiser water use.

Opposition to Water Reuse

Public opposition to water reuse has hindered implementation. Historically, Americans have opposed water reuse due to the "yuck factor." As such, direct potable reuse projects faced great public opposition. People "have been trained for generations to provide separation in both time and space between their wastes and their water supplies" (NRC, 2012). It is interesting to note that *de facto* reuse of water, which is the indirect reuse of potable water through an environmental barrier, is more acceptable to the public. A 1980 report by the EPA "indicated that more than 24 major water utilities used rivers from which [treated wastewater] effluent accounted for over 50 percent of the flow under low-flow conditions (NRC, 2012). It "cannot be demonstrated that such 'natural' barriers provide any public health protection that is not also available by other engineered process (e.g., advanced treatment processes, reservoir storage)" (NRC, 2012). *De facto* reuse continues to play a large part in US water use, particularly for cities along rivers; natural buffers have become a widely accepted practice. Recently, reports on the transport of pharmaceuticals and personal care products have raised public outcry against *de facto* reuse. The problem lies in convincing users that potable reclaimed water is no different in quality than the water that they withdraw from water reservoirs. Thus, continued funding for transport of contaminants in water is necessary to gain credibility and harness public support. However, even though there remains much to learn, extreme technological leaps in monitoring and treatment technologies are available to utility companies to prevent water contamination. A poll by General Electric illustrates that "two thirds (66 percent) [of Americans] feel positive about water reuse..." whereas there is greater support for non-potable reuse plans rather than potable reuse (General Electric, 2012). While it was found that people "generally favor reuse that promotes water conservation, protects human health...as the water options become more tangible to people with specific proposed projects in their communities...the public's support wanes" (Troy, 2006). This, "not in my backyard" perception, is due to a variety of reasons which include: a fear of a drop in property prices, perceived social class distinction by differences in quality of water sources, sanitation, etc. As such, there remains much public opposition to implementation of water reuse technologies for a variety of reasons. It is in the interest of water reuse technologies to encourage public awareness and build trust through open and constant communication with the public.

Opposition to Greywater

Greywater, on the other hand, faces both opposition from public health advocates and the water reuse industry. The water reuse industry has not faced any case of human health problems and is “unwavering in its intent to maintain this record with diligent operation of water recycling” (Sheikh, 2010). Katherine Yuhas, a water conservation officer for the Albuquerque Bernalillo County Water Utility Authority describes the current mindset among water reuse industry officials very well, “It’s not very popular at all, frankly. We don’t promote the gray water program. We don’t offer rebates for it. The reason is that we treat water at our water reclamation plant to a much higher standard than you could in your yard.” (Riley, 2010). Ms. Yuhas’ words hint at disapproval by the water reuse industry of greywater use. A few more concerns cited by water reuse industry officials include: public confusion and association of greywater to high quality water recycling, reduction of sewage flows that may impair production of reclaimed water, reduction in carrying capacity of solids, and increased salinity in recycled water (Sheikh, 2010). Wastewater treatment facilities profit by selling their treated effluent as reclaimed water. Increased implementation of greywater systems will reduce sewage flows to water treatment facilities, which reduces profits. If one assumes that greywater can be retrieved from 80% of household water use—from baths, sinks, and washing machines—then only 20% is sent back to the sewage system from toilets for treatment in wastewater facilities. Thus, increasing popularity of “privatized” water reuse through greywater systems significantly threatens the livelihood and profit margins of the water reuse industry.

Policy Recommendations

Water is a national issue that requires local action, but it is also a local issue that requires national action. In a best-case scenario, the Federal and State governments will cooperate to set goals for water management and reuse. However, water is not a priority on the President's various initiatives. In fact, President Obama has proposed to lower 2015 funding for the Environmental Protection Agency to $7.89 billion, a cut of 3.8 percent that will reduce the EPA funded state revolving fund by $581 million to $1.8 billion (Ambrosio, 2014). In addition, the Army Corps of Engineers is also expecting a significant decrease in their budget by 100 million annually to reform inland waterways (The President's Budget for Fiscal Year 2015, n.d.). This reduction will lower available capital to loan to States for water infrastructure projects and make only a small dent in the $384 billion necessary to completely repair the nation's water systems. It is important for the White House to re-evaluate its priorities. While the President has emphasized US energy problems, he has failed to stress the connection between the two: 210 BGD of water is withdrawn to generate US thermoelectric power (Kenny, 2005). Even traditionally carbon-free sources of energy, such as nuclear energy, consume large amounts of water: "nearly eight times more freshwater than natural gas plants per unit of electricity generated" (Averyt, 2011). National leadership should acknowledge and communicate the strong relationship between energy and water and its connection to the country's wellbeing. As a result of the lack of attention and outcry, water reuse and infrastructure repair is moving at a pace that is not fast enough to address future water shortages. While water infrastructure remains "out of sight," it is important to bring this issue into the spotlight. A federal commitment to wiser water practices will aid grass root campaigns, such as the EPA's Watersense and Department of the Interior's WaterSMART campaign, by bringing more visibility, urgency, and action. Water availability and management affects all users, deserves national attention, and is an issue of national security. It is hoped that increased publicity by the media and government will convince the public to take water conservation much more seriously before action is too late. Lack of water conservation may lead to a depletion of fresh water supplies that may severely increase water costs for industry, municipalities, and agriculture, ultimately affecting all water users without specified water rate structures that fund future development and ecosystem protection. It is important to discuss what government can do now so that the US will be better prepared for water problems when they arise.

Thus, the Federal government may offer matching funds for development of sustainable water infrastructure and policy in respective communities. The Federal government should no longer fully finance water projects and place the financial and creative burden on communities because wise water use may differ by region. This allows communities to redefine tiered water rates and encourage ownership amongst people to pay fees that directly benefit their communities. Federal investment, however, should support sustainable infrastructure that empowers their communities to directly reuse reclaimed water, invest in water research for their State, and evaluate the opportunity cost of water for other uses of higher economic value. Today, the EPA has opted for softer approaches, providing guidelines for water reuse and reports detailing infrastructure information. Unfortunately, the EPA has found that its reports have not effectively encouraged local State governments to adopt the same policies. The benefit of a national initiative and local action is that government officials are able to spread awareness and harness support, while simultaneously solving their respective community's water problems with solutions that fit their needs. Included are policy recommendations that may be used to initiate discussion regarding how US governments can manage water resources sustainably.

Federal Government Incentivizing Local Action

While water is a national issue, it requires local action with help from the Federal government. The Federal government should incentivize state governments to seriously address their water issues, using each state's respective water experts to determine effective courses of action in their own regions. Who better to govern than the constituents of local communities? While the state revolving funds for drinking and clean water have been able to support projects in the past, the loan program can only accomplish so much. New legislation by the Federal government can help local communities attain necessary funding to complete sustainable water infrastructures. This legislation would stipulate that beneficiaries and users agree to pay interest and implement adequate pricing tiers on their withdrawals that account for watershed protection, academic research, and future water treatment infrastructure. Because local governments may not have the financial capability to invest in projects, cooperation with private industry can be a means by which counties and districts raise necessary funds, which may mean an increase in water prices. Federal funding can match funds raised by industry and local constituents, ensuring that the Federal government invests in an immediate need that pays for itself through investment in research and infrastructure that creates a more robust, and self-reliant water system for communities around the nation.

Expansion of the Environmental Protection Agency is one way the Federal government may be able to handle a larger influx of proposals from local governments nationwide. An example of a similar organization that reviews proposals across the US is the National Science Foundation. Rather than review research proposals, an EPA water infrastructure board composed of water experts around the US will analyze projects for increased sustainability—including adequate fees and pricing tiers— feasibility, opportunity for reuse, and chance of success to strengthen infrastructure and research. By doing so, the Federal government incentivizes communities to seriously examine their water problems and offer solutions that will help both local communities and the broader US economy. Specifically, evaluators should identify the state's and community's commitment to self-reliance and independence from future help from the Federal government.

Potential Areas of Research

The initiative should also include a list of research focus areas. First and foremost, research on the transport of contaminants in all water systems is essential to protecting user health. The Federal government should continue to analyze how a variety of systems including direct potable reuse, *de facto* reuse, and greywater reuse can affect both the environment and human systems. Substantive research on the role of environmental buffers, such as discharge of treated wastewater effluent from rivers, can act as the deciding factor between whether or not a greater initiative for direct potable reuse will be considered and widely implemented. For example, analyses of the effectiveness of treatment by wetlands can be used as a means to support greater visibility of water treatment facilities that doubles as what the public may think is a "natural barrier." A wetlands treatment facility provides not only water treatment, but acts as a natural park for residents and promotes the growth of the natural environment. Talking Water Gardens wetlands located in Albany, Oregon, provide secondary treatment for metals and temperature contaminants from the city and a nearby metals facility before discharging the effluent back into the river for downstream users, protecting and restoring wildlife habitat in the process. The Talking Water Gardens is a great example of how the Federal government funded the cooperation of a small municipality and industry partner to treat waste streams that would have required expensive facilities to build individually.

Increasing expenditures on technical water research will provide the necessary background research to firmly recommend potable water reuse and sustainable water infrastructure. While the public supports direct water reuse, projects are not being implemented due to lack of public support when project proposals are closer to fruition. In order to change public opinion and policy, a combination of factors including water scarcity, time, and education will influence public views. The current drought in California has already forced some districts, such as Orange County, into directly reusing their water. According to Mike Markus, the general manager of the Orange County Water District, “as the [water] shortages become more extreme and water supplies are cut, it has raised awareness that we need to find alternative sources” (Monks, 2014). In response to the third successive year of drought in California, the district has increased its water reuse infrastructure capacity from 70 MGD to 100 MGD, enough water to provide for roughly 850,000 residents (Monks, 2014). However, for wider acceptance, increased implementation, and public safety, research on the transport of chemicals and treatment is needed. In a national survey of 50 large wastewater treatment facilities, more than half the samples tested positive for at least 25 drugs, which include oxycodone, high blood pressure medications, Tylenol, and ibuprofen (Fallik, 2013). Thus, in order to quell public worry and discontent, the Federal government needs to ensure that either pharmaceutical companies or government invests in research that reassures Americans that water supplies are safe. Including research costs in the fees associated with water delivery and infrastructure development is needed to create a more robust, and sustainable system that conserves water and encourages better horizon planning for water use.

The potential for nano-technology as a tool for water treatment has yet to be fully understood and can play a greater role in treatment facilities. Nanoparticles, such as titanium dioxide, have already displayed promising results in water treatment. Tests have shown that nano-filtration membranes have been able to remediate brackish water for potable use (Hillie, 2007). Continued research on inexpensive and effective nanotechnology for water remediation can significantly reduce water treatment costs and may eventually be able to treat trace pharmaceuticals and other chemicals in US waterways. A research initiative that includes these components, among others, can profoundly affect the way the public and scientists view wastewater reuse and treatment.

Another notable research area is in the implementation of aquifer recharge and storage (ASR) wells. ASR wells offer a means to store water in wetter months and save for drought conditions. Northwestern states have traditionally relied on summertime snowpack melts for field irrigation and water supply. However, “melting of the snowpack is sensitive to temperatures, which is predicted to increase in Oregon as Earth’s climate changes,” resulting in snowpack that melts before its flows can be used in the drier summer months (Pyne, 2005). ASR wells can play an integral part in recovery, storing water when surface flows are high, and used when low river flows prevent sustainable withdrawals from sensitive ecosystems. Preliminary research conducted on the implementation of recharge wells in Salem, Oregon has shown an energy savings of 4.1 MWH annually (Pyne, 2005). As climate change reduces summer flows and snowpack melts earlier, water availability decreases when it is needed most. Comprehensive implementation of ASR wells that negate the negative balance of consumption can offer long term groundwater sustainability. Injecting low mineral content rainwater or surface waters into aquifers can improve water quality by diluting mineral concentrations in water. In addition to improving groundwater quality, pilot studies on small-scale ASR wells have displayed recovery of the water table from 260 feet below the surface to 50 feet below the surface (Pyne, 2005). Because ASR wells have displayed an opportunity for Americans to save water for use when it is most needed, it is important to increase research on regional aquifer recharge projects to improve scientific understanding and likelihood of successful implementation of ASR wells. These research areas are only but a few areas that government should be incentivizing in its Universities and private sector industries.

Analyze Opportunity Costs

Currently, agriculture and industry do not compete for water. Traditionally, the Federal government provides interest free payback for agricultural users to use water delivered water infrastructure built with federal funding. For instance, Chapter 12, Title 43 in the US Code states that water supplied by the Bureau of Reclamation shall be paid interest-free for 10 years, “in no case shall the interest-free period exceed ten years” (43

U.S.C). However, this has not always been the case. For instance, by 2002, farmers in the Central Valley Project (CVP) in California had only paid back 11% of their $1billion 1936 agreement (Environmental Working Group (EWG), 2005). So, even though payments were interest free, farmers still failed to meet their end of the bargain. Since then, farmers have continued interest-free payments at the expense of taxpayers. At the same time, these farmers are receiving water at ridiculously low prices, approximately $17.14 per acre-foot, 1 cent per 190 gallons (EWG, 2005). However, if irrigators were charged operation and maintenance costs of the water delivery system, they should have paid at least $38.93 per acre-foot; a price that is still well below the funds needed to preserve surrounding ecosystems and pay for future infrastructure (EWG, 2005). While the latter pricing structure accounts for operation, supply, and maintenance, "such prices do not convey the opportunity costs—the economic benefit forgone when water is dedicated to a particular use—thus do not allocate the resources to its highest value use" (Congressional Budget Office, 2006). The opportunity cost of pre-allotted water to farmers could mean loss of water needed to generate sustainable energy, use in green industries, etc. Government can no longer spend in deficit and must make investments in infrastructure that sustainably pays for itself. It is time that industry and agriculture begin paying for water at reasonable prices that encourage allocation of water to uses that demonstrate high opportunity costs.

The coupling of new legislation and implementation of water markets may be one avenue that the Federal government can use to encourage States to manage water. Water rights are connected to the land, which means that when one buys land, s/he buys the water rights that have been determined when the land was first claimed. As a result, water may be allocated to lower yielding crops that could be better used to irrigate "high value" crops based on location. However, separation of land and water rights will allow users to trade water supplies much more easily, allowing market prices to dominate transactions that will enable water to reach high-value uses. Chile separated land and water rights in 1981 and has found reasonable success in management of its water storages. Doing so has encouraged water markets where behaviors are no longer controlled by the financial cost of water, but by the opportunity cost (Briscoe, 1996). Literature has also shown that market systems reduce net income loss when water flow in irrigation districts is reduced. Maass and Henderson discovered that when water flows to irrigation districts are reduced, losses in income in market systems are significantly lower, by 10 to 20%, than other water systems (Maass, 1978). The Northern Colorado Water Conservancy District is an example of a successful model in the US. The market is run by a "transparent user-based administration, which has its main underlying structure in the 'ditch-companies'" (Marino, 1999). Ditch companies purchase water rights and develop infrastructure to deliver water to its users who purchase stock in the company, which correlates to an amount of water based on the number of stocks one owns. In addition, users also pay annual fees that cover operation and maintenance of their water supplies. This way, users can buy and sell water rights to users within the same district, ensuring that water goes to its most beneficial use, prevents unnecessary losses in income in years of drought, and eliminates concerns that cities will steal water from agricultural districts because they have greater buying power. While water is a State issue, the Federal government can place pressure on local governments to develop more effective schemes to save water and increase economic output, especially when droughts decrease agricultural output and increase costs. By treating water as an economic good, it is traded to users who have the most use for water at that time, ensuring that water is always transported to its most beneficial use.

The creation of water rates that reflect the true cost of water consumption will further encourage users to rethink consumption. Current water rates reflect the cost to transport and treat water. Costs, however, must also reflect the projected impact on the environment, the availability of water, and future infrastructure costs to be sustainable. By doing so, the nation will be able to offer watershed protection and invest in aquifer recharge to prevent depletion of the nation's most valuable resource. It is recommended that communities offer a tiered rate structure for water usage to encourage users to reduce water consumption. The program is meant to reward consumers who exhibit appropriate water usage by offering them lower rates. Several water-stressed areas, such as Orange County, CA, Boulder, CO, and Colleyville, TX have already adopted water rate structures to encourage residents to lower water consumption. While many States have implemented these policies, the tiers are not drastic enough to encourage users to seriously adjust their lifestyles or implement water saving technologies such as low flow systems and greywater systems. Figure 4 includes an example of the Colleyville tiered water rate program.

In addition to the minimum bill of $12.52 for the first 2,000 gallons of water used by a customer, the current charge for every 1,000 gallons of water is $3.74, regardless of the amount of usage. (Sewer charges are billed at a flat monthly rate, as determined by volume usage for individual customers during the winter months.) With tiered rates the cost breakdown by usage is as follows:

- 2,001-20,000 gallons - $3.74

- 20,001-30,000 gallons - $4.30

- 30,001-40,000 gallons - $4.86

- 40,001-50,000 gallons - $5.42

- Over 50,000 gallons - $5.98

In the progressively tiered system, once usage elevates to the next tier, every 1,000 gallons of water will be charged at the rate for that tier. Water bills will be calculated so that water used in the lower tiers is charged at that tier. Bills will provide a snapshot of the portion of water use from each tier.

Customers using 20,000 gallons of water a month or less, which covers general household usage and basic lawn irrigation, will not see an increase under the tiered structure. Those using up to 30,000 gallons of water per month will see an increase up to $5.60 a month, from $117.24 to $122.84. For instance, that customer will be charged under two tiers—the first 20,000 gallons at $3.74, and from 20,001 to 30,000 gallons receiving a rate of $4.30. Up to 40,000 gallons per month, the increase would be $16.80; usage up to 50,000 gallons a month would result in a monthly increase of $33.60; and, the highest use customers utilizing more than 50,000 gallons in a month would see the largest increase--so that a customer using 60,000 gallons a month would see an increase of $56.00.

Figure 4. Colleyville, TX Tiered Water Rates
Source: http://www.colleyville.com/tieredwaterrates.html

Nationally Standardize Greywater

US water law is as diverse as it is confusing. Each State has devoted resources to developing each of its water use and quality frameworks by which water is distributed and owned. The prior appropriation and riparian doctrines impede development across State borders because new interstate projects must abide by bodies of law that differ from State to State, even if both States follow similar doctrines. The US government has already experienced the shortcomings and frustrations associated with diverse water laws. Greywater, however, is a largely untouched area of water law that government can simplify and standardize. Greywater can account for "as much as 50% of indoor potable water use and [meet] about half of the demand for outdoor irrigation use during the irrigation season" (Shiekh, 2010). Advocates for greywater systems have also cited that there have been no documented cases of public health impacts associated with greywater

(Shiekh, 2010). Greywater systems reduce withdrawals and consumption, thereby reducing energy costs to treat and pump water to residential or commercial areas and back to treatment facilities. In addition, greywater decreases discharge to sensitive water bodies, decreases diversion of freshwater from sensitive ecosystems, and reduces pollution (EPA, 2013b). Unfortunately, water rates are so low that greywater systems often display very low cost-benefit analyses. A simple cost benefit analysis of a greywater system in Santa Barbara displayed an initial cost of $1131 and a savings of $35 per year over a payback period of 25 years (Sheikh, 2010). As costs attributed to treatment, energy, and scarcity increase, water prices will do so as well, “naturally” incentivizing users to install greywater systems. However, installation of sustainable technologies before climate forces require better management of resources will need incentives and education from the Federal government.

Currently, while most States regulate water recycling of reclaimed water at centralized facilities, only 30 States regulate water recycling of greywater (EPA, 2013b). As water availability decreases, States will individually grapple with standardization of greywater systems to lower demand, wasting money, time and resources on laws that can easily be written nationwide. A Federal standardization of greywater can establish a baseline for States to follow, especially when time arises when drought conditions worsen, influencing constituents to install greywater systems. Doing so, the Federal government would act on a small issue that prepares local State governments for possible future legislation. Thus, smaller governments can focus their efforts on other issues rather than wasting their time and efforts on an issue that can only benefit everyone. Currently, greywater reuse regulations differ from State to State; some States allow the use of kitchen sink water while others do not (examples of greywater regulations can be found in Bahman Sheikh's white paper on *Greywater*). Common themes among greywater regulation include:

1. No formal permit for private residences and flow below determined thresholds
2. Greywater may consist of effluent from washing machines, showers and baths, and (kitchen sinks)
3. Clear labeling on pipes and tanks regarding non-potable water
4. Prohibition of ponding or runoff
5. Greywater design should allow for 100% diversion of flow back into organized wastewater collection systems when not in use
6. Greywater must not affect quality of surface water or groundwater
7. A maximum retention time of 48 hours before discharge into municipal wastewater collections systems

The Federal government should take a "less is more" approach. State governments traditionally do not appreciate when the Federal government steps on their "rights", especially when it comes to water. As such, the Federal government should frame greywater regulation and guidelines in manners that reduce the work required in States, rather than the State-by-State approach currently in practice across the US. Designating purple, or another color for pipes, will allow simpler identification of greywater systems across State borders. States should be able to determine thresholds for greywater use, which may follow a guideline of 100 gallons per person per day per residence. For example, a family of five is allowed greywater discharge of up to 500 gallons per day, based on national averages on individual water use. Bacterial concentrations in kitchen sink have been one of the factors limiting its use in certain States. Further research on potential health effects of adding kitchen sink effluent should be researched to reduce public concern for safety.

While private residences do not need to apply for formal permits to install greywater systems, State governments should ask that interested people register to a national online database to receive informational packets and guidelines for developing private greywater systems. Online registration will allow governments to track greywater interest by county and state, as well as gain rough estimates on probable locations where installation of greywater systems might occur, rather than the inconsistent piecemeal approach in practice today. Tracking data allows researchers to determine effects of greywater systems and locate areas in the event that any issues arise. As greywater systems become more popular at the individual level, larger greywater policies can be developed at the state level depending on public interest. The city of Tucson, Arizona has progressively adopted ordinances requiring that:

> "All new single family and duplex residential dwelling units shall include either a separate multiple pipe outlet or a diverter valve, and outside 'stub-out' installation on clothes washing machine hook-ups, to allow separate discharge of graywater for direct irrigation."
>
> "All new single family residential dwelling unites shall include a building drain or drains for lavatories, showers, and bathtubs, segregated from drains for all other plumbing fixtures, and connected a minimum three (3)

feet from the limits of the foundation, to allow for future installation of a distributed graywater system"

(City of Tucson, 2008)

Support Sustainable Community Development

Traditionally, the Federal government has encouraged development of certain technologies by offering subsidies. For instance, the renewable fuel standard increased ethanol market prices and encouraged ethanol technological development by offering federal tax credits for blending ethanol with gasoline. Other examples of government subsidies include installation of solar panels, hybrid vehicles, fossil fuels, agriculture, telecommunications, etc. What about water? The US government has subsidized water use, discouraging wise use of water and allowing US water prices to be one of the cheapest worldwide. Agricultural users are provided water at highly subsidized prices, which can "divert resources from more productive to less productive uses, thus reducing economic efficiency" (Steenblik, 2014). In addition, the prior appropriation doctrine encourages users with water rights to use their full allotments of water to avoid the risk of losing their rights. However, the opposite of this should be true; users should be encouraged to reduce water usage, rather than subsidized to consume it. In recent years, LEED-certified[12] buildings and communities have encouraged homebuyers and buildings to live more sustainably. LEED acts as a rating system that enables buyers and industry to determine sustainable design, construction, and operation of any building. The system currently focuses on building materials and energy usage.

A similar model can be used for apartments and buildings that implement and sustainably use efficient water systems. An incentive package that offers tax credits in

[12] LEED represents Leadership in Energy and Environmental Design.

either refunds or deductions for those that install greywater systems or withdraw and consume water within certain quotas should be rewarded. While some technologies have been subsidized, sustainable living should be the aim. Thus, quotas in water reduction should be in place that allows users to address both problems, whether by technology or by changing their lifestyles. A combination of better implementation of water infrastructure in homes, individual effort to reduce water intake, and increased withdrawal costs will hopefully encourage users to be more mindful of their water usage. Another method that State governments can use to speed up this process is by offering incentives for builders developers to create greener communities. Alternatively, newer communities can install smaller wastewater treatment facilities that treat community water to non-potable reuse standards to irrigate local parks and public areas. Traditional fears of drops in property prices and class differences should be reframed. Implementation of water reuse, either through greywater or reclaimed water, should be marketed as methods people can live sustainable LEED lifestyles, mirroring why people invest in electric vehicles and clean energy. Urban renewal that already incorporates the use reuse of materials should also stress reduction of water consumption by way of reuse.

A treatment wetland can be installed to treat municipal waste and provide a recreational area for the public. Constructed wetlands offer a visibly 'natural' water treatment that restores wildlife and garners public trust of wastewater treatment. Implementation of these systems in direct water reuse schemes can act as natural buffers in *pseudo de facto* reuse of water sources and address public safety concerns. While direct reuse may be ideal, public opposition might too strongly oppose any implementations plans. Indirect or de facto reuse offers the best and most accepted option to release reclaimed water back into rivers for downstream users or pumped into aquifers for later use. It will face much less public opposition and can be used as a current means to gradual containment of the nation's water crisis. As water options become more restricted, direct water reuse will have to be implemented. By that time, hopefully research will have caught up to prove that the benefits of direct reuse and greywater systems outweigh the costs.

Apply Behavioral Economics

The application of behavioral economics[13] to water usage will also encourage better water usage. Behavioral economics applies pro-social behavior, which is the idea that people care about the welfare of others, examples include: volunteering time at soup kitchens, donating blood, voting, and helping strangers. Because people care about how others perceive them, "social comparisons lead to significant reductions in average water use" (Ferraro, 2011). Thus, by comparing one's water use to that of the median of the neighbors, utilities and municipalities can reduce demand for water. Rather than forcing individuals to use less water, State governments can influence behavior by using comparative techniques. For instance, researchers discovered a 10% drop in energy consumption when utility companies asked users to reduce consumption "because [the] neighbors are doing it," rather than for "the good of the planet, the well-being of future generations, the financial savings," etc (Conniff, n.d.). Through the use of behavioral economic techniques, State and municipal governments can curb the high water usage of heavy users and encourage consumers to consciously evaluate their water practices. Local

[13] Behavioral economics is the study of the effects of social, cognitive, and emotional factors on the economic decisions of individuals and institutions and consequences for market prices, returns, and resource allocation. In this case, water can be seen as a cookie jar shared by the public. Because the cookies are shared and cookie withdrawals can be seen by everyone in the kitchen, one's cookie consumption is affected by what others might think of him or her.

governments can incentivize better water usage by comparing farmers' water consumption against one another, citing technologies that have been proven to work for other farmers in the area. Similar techniques can be used to increase installation of greywater systems. Instead of simply comparing users against each other, monthly bills can share how each other's neighbors are reducing their water usage. Utilities can influence the public to adopt certain types of measures and protocol using their data. The State and Federal government can attempt to set quotas for water use reduction which utility companies must meet, allowing utility companies and communities to develop creative means to reducing their water use.

While each one of these recommendations can reduce water demand, sustainable water management and practice is a comprehensive issue that requires multi-faceted technology and policy measures. While water markets, tiered water rates, research, and greywater standardization can help alleviate the issue, they might not solve the issue. Water rates must "rise above shadow rates for this quantity constrained resource" before people will begin to seriously reduce their water consumption and install low flow and greywater systems (Weinberg, 2002). Arizona's Tucson city ordinances are a great example of how cities are progressively trying to reduce water demand. While the current political climate may not be ready to appropriate funding for water projects, steps need to be taken to ensure that the US is prepared to repair its water infrastructure, lead more sustainable lifestyles, or develop water reuse infrastructure. Congress's approval of the Water Resources Reform and Development Act is a good step towards addressing US water issues. Water management and practice is a daunting issue, but one that the US government has handled in the past, and will continue to do so in the future.

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