AN EXAMINATION OF SAN FRANCISCO STATE UNIVERSITY STUDENTS' PERCEPTIONS OF POTABLE REUSE

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by

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CERTIFICATION OF APPROVAL

I certify that I have read An Examination of San Francisco State University Students' Perceptions of Potable Reuse by Charlotte Hummer, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree (Master of Art in Geography: Resource Management and Environmental Planning at San Francisco State University.

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Recycling water for drinking purposes, commonly referred as potable reuse, is currently under discussion as a way to diversify urban water supplies. A significant obstacle to implementing potable reuse is negative public perception. This research explores how attitudes and opinions towards potable reuse vary among college students depending on their academic major, as well as their understanding of and concern about tap water networks and drought conditions. A survey of students (n=163) at SF State found that the majority (68%) of participants were "very likely" or "likely" to support recycled water for drinking purposes in their municipality, and 61% were "very likely" or "likely" to drink recycled water. Students were more likely to support potable reuse and drink recycled water if they already drink tap water at home, are concerned about the drought in California, and believe that droughts will continue to increase in severity.

I certify that the Abstract is a correct representation of the content of this thesis

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Chair, Thesis Committee Date

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Introduction

Recycling wastewater for drinking purposes, commonly referred to as potable reuse, is considered a sustainable and resilient way to increase California's drinking water supply (NWRI, 2016). California has a long history of water stress due to prolonged droughts and population increases. Both of these factors are now exacerbated by climate change. Although recycled water has been used to augment drinking water in parts of California since the middle of the 20th Century, some members of the public are apprehensive about the concept of treating wastewater for drinking purposes. Research shows that the greatest obstacle to implementing potable reuse is negative public perception, while various experts insist that potable reuse is inevitable due to advances in water treatment technology and the need to diversify water supply (Millan et al., 2015; NWRI, 2016; Tchobanoglous et al., 2015). Exploring public concerns with potable reuse can help guide water experts on how to assuage these concerns through education, public engagement and project planning.

The nine counties of the San Francisco Bay Area are expected to see their population increase by 2 million residents by 2040 (SPUR, 2013). This projected population growth will significantly increase demand for fresh water. The projected Bay Area water demand with active water conservation measures is estimated to be 269 million gallons a day (mgd) in 2040 (BAWSC, 2015). While normal-year supply is enough to meet this projected demand, existing sources are projected to fall short by approximately 43 mgd in drought years (BAWSC, 2015) and dry periods are expected to become more frequent in California due to climate change (SPUR, 2013; Tchobanoglous et al., 2015). Even with effective water conservation efforts, water savings will eventually plateau (SPUR, 2013; Sedlak, 2014). Proponents point to potable reuse as a sustainable water supply because “the quantity of available wastewater does not decrease substantially during droughts, the treatment is cost effective, and it causes less damage to the environment than many of the alternatives" (Sedlak, 2014, pg. 188).

Research on public perceptions of recycled water has focused mainly on the various cognitive factors that impact perceptions, the socio-demographic elements that influence perceptions, and methods to foster public acceptance of potable reuse. Research on socio-demographic factors lacks insight into the perceptions of younger, better-educated populations. There is also an absence of research on the correlation between perception of potable reuse and public knowledge of water resources and environmental concerns. The objective of this thesis is to explore how attitudes and opinions towards potable reuse vary among college students depending on their academic majors, as well as their understanding and concern with tap water networks and drought conditions. Students at San Francisco State University (SF State) were surveyed in order to collect information on their water related behavior, knowledge and attitudes and to test four hypotheses:

1. Perceptions of potable reuse will vary with the student's academic major. Students in environmentally-focused majors will be more likely to express favorable attitudes toward potable reuse than students in health-related majors.
2. Favorable attitudes toward potable reuse are more likely to be expressed by students who currently drink tap water.
3. Favorable attitudes toward potable reuse are more likely to be expressed by students who are knowledgeable and concerned about the California drought.
4. Favorable attitudes toward potable reuse are more likely to be expressed by students who are knowledgeable about existing potable reuse projects.

The results of this study have the potential to inform local water policy makers on the knowledge, behavior and perceptions of a younger, drought concerned and water conscious demographic in the San Francisco Bay Area. These study can also contribute to the body of literature on public perceptions of potable reuse that considers trust in authorities, perceptions of risk, socio-demographic elements, and effective public outreach as factors that influence perceptions of potable reuse.

This thesis will begin by reviewing the history of potable reuse to provide context before reviewing the literature on perceptions of potable reuse. The survey methodology is explained in detail, including survey design and data analysis. Results of the survey and data analysis are then reported, followed by a discussion of the main themes and findings from the study.

Background

Recycling wastewater for various uses has been a long-standing practice, but recycling wastewater specifically for drinking purposes (potable reuse) has been practiced only since the middle of the 20^{th} Century. California's first potable reuse project, known as the Montebello Forebay Groundwater Recharge Project, started in 1962 in Los Angeles County. Although many other potable reuse projects have followed, experts note that wastewater has inadvertently augmented the drinking water supply for much longer through unplanned *de facto* reuse (Crook, 2010; Sedlak, 2014; Tchobanoglous et al., 2015; USEPA, 2012). *De facto* reuse refers to drinking water derived from a water source subject to upstream wastewater discharges (Tchobanoglous et al., 2015; National Water Research Group, 2016; USEPA, 2012).

Aside from unplanned *de facto* reuse, there are two techniques of planned potable reuse referred to as direct potable reuse (DPR) and indirect potable reuse (IPR). Both techniques undergo advanced water treatments, however IPR utilizes an environmental buffer before the water is withdrawn for drinking purposes, while DPR does not (Tchobanoglous et al., 2015). Historically IPR has been more widely practiced but significant advances in water treatment technology have made DPR a viable option for many communities seeking an alternative water supply (Crook, 2010). Yet despite the technological advances in water treatment technology and successful potable reuse projects, there is still public apprehension surrounding the concept of recycling wastewater for drinking purposes. The following section will review the history of potable reuse while discussing advances in wastewater treatments as well as the differences in potable reuse techniques.

Recycled Water

The Clean Water Act of 1972 requires that communities and factories treat wastewater sufficiently to safely discharge it into the environment (Bruvold et al., 1981; Schulte, 2011; Tchobanoglous et al., 2015). The higher standards of wastewater effluent mandated by the Clean Water Act required wastewater treatment plants to upgrade their facilities, creating a higher quality effluent that can be used for various non-potable uses. The Clean Water Act also regulates effluent discharge into navigable waterways through the National Pollutant Discharge Elimination System (NPDES) (USEPA, 2012). This forces wastewater facilities to find alternative ways to reuse the effluent, such as irrigation for golf courses and agriculture.

Recycling wastewater for non-potable purposes became popular throughout the U.S. in the 1970s with support from water managers, engineers and government officials (Meehan et al., 2013; Sedlak, 2014). A growing number of farms in California also began using recycled wastewater for irrigation during the 1980s and 1990s. This not only helped the agricultural businesses, it simultaneously provided wastewater treatment plants with another place to discharge their effluent (Schulte, 2011). In the 1990s water utilities began expanding their recycled water infrastructure for delivery to urbanized areas to be used for irrigating sports fields, schools and playgrounds and as well as for industrial cooling (Sedlak, 2014).

Although potable reuse was practiced in several areas in the U.S. before the Clean Water Act, the majority of recycling was for non-potable uses. The first potable reuse project in the U.S. was developed as an emergency measure to save a community in Chanute, Kansas from a disastrous drought in 1956 (Crook, 2010; Sedlak, 2014). The project was only in operation for five months before the drought ended and the community was able to resume use of its original drinking water supply (Crook, 2010). Although this potable reuse project was temporary, it demonstrated that municipal wastewater could be treated to drinking water standards.

Potable Reuse

Potable reuse, both direct potable reuse (DPR) and indirect potable reuse (IPR), employ advanced water treatments. Advanced water treatment is a general term used for various processes administered after initial wastewater treatment, including microfiltration, reverse osmosis, ozone and advanced oxidation processes (Tchobanoglous et al., 2015).

IPR, the most common technique of potable reuse, employs an environmental buffer after advanced water treatment, but before introduction into the local water distribution system (Tchobanoglous et al., 2015). The environmental buffer can be a groundwater aquifer, a surface water reservoir, or a lake or river that allows the water to be further purified through natural processes, as well as stored and blended with other drinking water supplies before being distributed through the potable water infrastructure (Tchobanoglous et al., 2015). Groundwater aquifers are the most commonly used environmental buffer because they can simultaneously store the water, replenish the groundwater table and block saltwater intrusion in coastal regions. The water is introduced into the groundwater aquifer either by infiltration through spreading basins or injection into groundwater wells. The blended water in the environmental buffer is retreated and tested before distribution to the public (Tchobanoglous et al., 2015; USEPA, 2012).

Water Factory 21 is one of the most well known IPR projects, contributing 10% to the total drinking water supply in Orange County (Meehan et al., 2013; Ormerod & Scott, 2012). Water Factory 21 was originally designed in 1977 to repel saltwater intrusion along the Orange County coastline (OCWA, 2014; Sedlak, 2014). The Orange County (OC) Water District partnered with the OC Sanitation District to reuse treated wastewater that would otherwise be disposed of into the Pacific Ocean, while providing additional fresh water to help repel saltwater intrusion (OCWA, 2014; Sedlak, 2014). The process subjects wastewater effluent to microfiltration, reverse osmosis, UV light treatment and hydrogen peroxide (OCWA, 2014; Sedlak, 2014). This highly purified water is then injected into a string of groundwater wells called the Talbert Barrier, which are strategically positioned to push saltwater back towards the coast (Sedlak, 2014). This process also supplements the drinking water supply by replenishing the groundwater (Ormerod & Scott, 2012; Sedlak, 2014; OCWA, 2014). Water Factory 21 was temporarily shut down in 2006 in order to remodel and expand with top of the line technology; it reopened in 2008 as the Ground Water Replenishment System (http://www.ocwd.com/gwrs/).

Direct potable reuse is similar to IPR, except that it does not use an environmental buffer. Instead, the advanced treated water is introduced directly into the potable water distribution system. According to Meehan, Ormerod and Moore (2013) the first direct potable reuse system in the world was developed in Windhoek, Namibia in 1968. This region in sub-Saharan Africa has now been successfully treating wastewater to potable standards for four decades (Espinola, 2016). The facility was upgraded in 1997 and now produces 5.5 million gallons a day (USEPA, 2012). Once a radical idea, DPR is now regarded by water resource managers as a viable option for urban communities looking for ways to expand their drinking water supply. DPR can also be more advantageous in urban environments where space is limited, because it does not have to rely on site-specific attributes for an environmental buffer (Meehan et al., 2013). Although DPR offers more flexibility than IPR, it also raises more issues around health concerns, project management, operations and public perceptions (Crook, 2010).

There are only two functioning DPR facilities in the US, but another is expected to come online soon (Espinola, 2016; Nagel, 2015; Tchobanoglous et al., 2015). The two functioning DPR facilities are in Big Springs and Wichita Falls, Texas. Both use treatment technologies accepted by regulatory authorities and the public (Nagel, 2015). El Paso, Texas is also piloting a DPR project that will soon produce 10 million gallons per day of drinking water (Espinola, 2016). Although regulatory authorities have accepted those DPR facilities, they have done so on a case-by-case basis (Tchobanoglous et al., 2015).

The lack of California state regulations for DPR has made it very difficult to establish DPR projects in California. The California Legislature enacted Senate Bill (SB 918), which initiated investigation of the feasibility of developing uniform water recycling criteria for DPR by December 2016. This initiative sought to legitimize the DPR process by formalizing standards and procedures for facilities seeking to supplement local water supply in California. An expert panel of scientists and engineers was convened to study the technical and scientific issues, and an advisory group of stakeholders was assembled to advise the expert panel and the State Water Board in assessing the feasibility of developing uniform recycling criteria (State Water Resources Control Board, 2016). The expert panel found that it is "technically feasible to develop uniform water recycling criteria for DPR in California, that those criteria could incorporate a level of public health protection as good as or better than what is currently provided by conventional drinking water suppliers and IPR" (State Water Resources Control Board, 2016, pg. IV). Taking recommendations from both the expert panel and advisory group, the State Water Resources Control Board delayed the adoption of regulations for DPR pending further investigation into the identified knowledge gaps in regards to reliability, public health and acceptance of DPR in California. The expert panel recommended improving monitoring of source and treated water, implementation of a probabilistic method to confirm the necessary removal values for viruses in DPR treatment trains, monitoring of pathogens in raw wastewater, collecting raw wastewater pathogen concentration data, identifying options for final treatment processes to "average" potential chemical peaks, and developing comprehensive analytical methods to identify unknown contaminants (State Water Resources Control Board, 2016). Although the adoption of the regulations cannot take place before the key research recommendations are addressed, the State Water Board can begin the process of developing criteria for DPR.

One of the facilities that could benefit from streamlining of the California DPR criteria is Santa Clara County's Silicon Valley Advanced Water Purification Center. The $72 million facility uses tertiary treated water from a sewage treatment facility and applies advanced treatment technology similar to the OC Ground Water Replenishment System. This highly treated water is currently used for non-potable purposes such as irrigation and industry even though it surpasses current drinking water standards (Standen, 2013). Santa Clara County's goal is to provide potable water to local residents by 2025, but they "believe it will happen even sooner" (J. Fiedler, personal communication, November 19, 2014). The California DPR regulation could provide guidelines for Santa Clara County to plan a DPR method of potable reuse, rather than planning an IPR project that would require additional infrastructure and an environmental buffer. Through facility tours, informational pamphlets, and public education about the water purification process, they are seeking to build public trust and support for potable reuse.

While the Silicon Valley Advanced Water Purification Center is well prepared to implement potable reuse in Santa Clara County, other projects in California including San Diego's Water Repurification Project have been trying to pursue potable reuse since the early 1990s (Bridgeman, 2004). The San Diego Repurification Project first proposed an IPR system that would subject tertiary treated wastewater from San Diego's North City wastewater treatment plant to various advanced water treatments before pumping it to the San Vicente reservoir for storage. After a severe drought in the 1970s, San Diego realized the importance of diversifying its water supply (Bridgeman, 2004). However, the project received great public and political scrutiny and ultimately was cancelled by San Diego City Council in 1999, in part due to inadequate dissemination of information and poor stakeholder outreach (Bridgeman, 2004; Hartley 2006). Since then the City Council of San Diego has authorized several initiatives exploring the feasibility of potable reuse. It funded a demonstration project from 2009 to 2013, which confirmed that the city could successfully produce recycled water that meets federal and state drinking water standards (Pure Water San Diego, 2016). San Diego's potable reuse project, now called Pure Water San Diego, is planning to provide one-third of the city's drinking water supply by 2035 (Pure Water San Diego, 2016).

Public apprehension around San Diego's potable reuse project was accentuated by the phrase "toilet-to-tap," coined to rebuke the concept of potable reuse by the media. The phrase is claimed to be one of the major inhibitors of the success of potable reuse projects since the early 1990s (Meehan et al., 2013; Ormerod & Scott 2012; Sedlak, 2014). According to Sedlak (2014) the well-known late night talk show host Jay Leno joked about Miller Beer being made from toilet water from the Los Angeles water-recycling project. Miller Brewing Company sued the water utility and encouraged local citizens to protest with signs using the catchy slogan (Sedlak, 2014).

There is little doubt that the "toilet-to-tap" protest interfered significantly with the progress of recycled water for potable use (Meehan et al., 2013; Ormerod & Scott, 2012; Sedlak, 2014). This slogan is particularly frustrating to many water resource experts because unplanned *de facto* reuse has been supplementing drinking water for centuries (Sedlak 2014). *De facto* reuse is common in our world today; in fact many places around the world already get their water from streams and rivers that carry wastewater, like the Yangtze in China, the Thames in England, and the Mississippi in the U.S. (Meehan et al., 2013). Although *de facto* reuse is common in many sources of drinking water, conventional wastewater treatment cannot completely remove trace organic chemicals found in wastewater, which can introduce these containments to downstream drinking water sources (USEPA, 2012). As a result, numerous studies have been conducted on the implications and risks of these containments for conventional drinking water supplies as well as planned potable reuse.

Although Earth's water is naturally recycled through the hydrologic cycle, urbanization has created two different types of water: wastewater and potable water. This distinction makes it challenging for water resource managers to introduce potable reuse to a public that often finds it repulsive or too risky due to potential water contamination from microorganisms, organic compounds, and constituents of emerging concern (CEC) (Dolnicar & Schäfer, 2009; USEPA, 2012). CECs include chemicals or compounds that are used in pharmaceuticals, nonprescription drugs, personal care products, household chemicals, food additives, flame retardants, plasticizers, and biocides that can have environmental and human health effects by their hormonally active agents, endocrine disrupters or endocrine disrupting compounds (USEPA, 2012). These CECs are not yet regulated under national drinking water standards for advanced treated water, but some are on the Drinking Water Contaminant Candidate List (Tchobanoglous et al., 2015; USEPA, 2012; NRC, 2012). Due to the broad range of chemical properties in CECs there is no single treatment process for all potential chemicals or compounds (USEPA 2012).

CECs and other potential water contaminents raise understandable health concerns. However, some experts claim that advanced treatment technologies for potable reuse are able to remove trace chemical constituents throroughly enough to pose very little risk for human health (Tchobanoglous et al., 2015; USEPA, 2012). The National Research Council (2012) acknowledges that “health hazards posed by long-term, low-level environmental exposure to trace organic contaminants in reclaimed water or from de facto reuse scenarios are not well characterized, nor are their subsequent health risks known” (pg. 108). Although long term health risks of trace chemicals are still unknown, the US EPA (2012) states, “Because a human health risk of zero is not an achievable condition with exposure of any level, it is necessary to reach a consensus on upper bound *de minimis* risk goals that can be the basis for design and operation of planned potable reuse facilities” (USEPA, 2012, pg. 6_15). According to Wintgens et al. (2008) a number of toxicological tests and a limited number of epidemiological tests on IPR projects in San Diego, South Australia, the United Kingdom and Germany did not show “a higher health risk is connected to water recycling than to the use of the conventional sources considered” (pg. 104). Although potable reuse projects are already being practiced in various places in the world, public apprehension concerning various factors including legitimate health risks continues to be the greatest obstacle when implementing new potable reuse projects.

Literature Review

Research on public perceptions of potable reuse fall into three main categories. One category of research examines cognitive and emotional factors that affect public perceptions of potable reuse (Dolnicar & Schäfer, 2009; Friedler et al., 2006; Higgins et al., 2002; Kantanoleon et al., 2007; Meehan & Ormerod, 2013; Ormerod & Scott, 2012; Po et al., 2003; Tricoche, 2014). Another body of research examines demographics of likely acceptors or rejectors of the concept of potable reuse (Dolnicar & Schäfer, 2009; Friedler et al., 2006; Hartley, 2006; Ishii et al. 2015; Po et al., 2003). Finally, some recent research focuses on how to foster acceptance of potable reuse (Bischel et al. 2012; Hartley, 2006; Marks, 2006; Millan et al., 2015; Ross et al., 2014; Tchobanoglous et al., 2015; Tennyson et al., 2015; USEPA, 2012). Whether the studies of perceptions of potable reuse examine what people think, who thinks what, or how to influence what people think, this research has interesting discoveries as well as notable gaps.

Factors Affecting Perceptions

Public aversion to potable reuse is evident from the visceral disgust that many people express when contemplating the concept (Ormerod & Scott, 2012; Po et al., 2003; Tennyson et al., 2015). This psychological reaction to the concept of consuming recycled water is commonly referred to as the "yuck factor" (Po et al., 2003). Early research on public perception of wastewater reuse established this psychological barrier, and concluded that the public was not ready for such "intimate" uses of reclaimed water (Baumann, 1983; Bruvold & Ongerth, 1974). Bruvold and Ongerth (1974) interviewed about 100 individuals from 10 different cities in California to assess the difference of opinion in communities that were already receiving reclaimed water for certain services and communities that were not. The results showed that whether or not they were in a community that used reclaimed water, individuals expressed opposition towards the use of reclaimed water for drinking and food preparation.

According to Meehan et al. (2013) this psychological barrier of disgust toward potable reuse can be further explained by framing recycled effluent as a parallax object, "a material force that disrupts the power geometries embedded in municipal water management" (pg. 67). Since the early 19th century, wastewater infrastructure has been engineered to flush polluted water away — out of sight and out of mind (Meehan et al. 2013). The goal has been to lessen the risk of infectious disease caused by waste disposal in rapidly growing urban areas (Meehan et al., 2013, Ormerod & Scott, 2012; Sedlak, 2014). The scientific understanding in the early 19th century was that disease was caused by the smell of sewage and waste, called miasma (Sedlak, 2014). Many large cities in Europe and North America built systems to quickly remove wastewater from homes via sewer systems (Sedlak, 2014). The sewer system created the "normal" metabolic flow of urban water by engineering a system that put wastewater underground and away from any public contact. With wastewater "out-of-sight and out-of-mind," the public grew unfamiliar with and disgusted by both the sight and smell of it.

Ormerod and Scott (2012) explain how potable reuse represents "matter out of place," because it violates cultural norms, urban order, and long-standing practices that keep wastewater and drinking water separate due to health concerns. Rerouting this normalized urban water flow, potable reuse captures wastewater before it is discharged to the nearest receiving water body and brings it back into the system it was discarded from. Not only does this violate the urban norm, it also elicits an emotional reaction from people and triggers fear of health risks (Meehan et al., 2013).

Risk perception affects individuals' attitudes toward potable reuse (Dolnicar & Schäfer, 2009; Ormerod & Scott, 2012; Po et al., 2003; Tricoche, 2014). Risk perceptions are culturally constructed; the depth of understanding one has of a particular issue varies, as do the rationales, values, and beliefs one engages when evaluating risk (Ormerod & Scott, 2012). Issues regarding health are the most commonly perceived risks associated with wastewater reuse, especially when considering its consumption by or contact with children (Po et al., 2003). In a study that compared public perceptions of desalinated water and recycled water in Australia, health risks were among the three main concerns for both, with recycled water perceived as being more risky than desalinated water for consumption (Dolnicar & Schäfer, 2009). This study used an Australian permission-based internet panel to conduct a comparative analysis of the knowledge and perceptions of recycled and desalinated water (Dolnicar & Schäfer, 2009). In this study, 61% of survey respondents listed health-related concerns about recycled water (Dolnicar & Schäfer, 2009). Not only did respondents believe that recycled water contained more microorganisms, they also believed it contained more chemicals for disinfection than desalinated water (Dolnicar & Schäfer, 2009). The study was inconclusive regarding which alternative water source the public preferred, but was able to determine that the public discriminates based on how the alternative water source might be used. When given the choice, the public opts for recycled water to be used for applications furthest away from the body, such as the irrigation of golf courses and highway medians.

Public perceptions of risk associated with potable reuse can be particularly frustrating to potable reuse proponents who assure the public that the risks are very small (Ormerod & Scott, 2012; Po et al., 2012). According to the National Research Council (2012), "following proper diligence and employing tailored advanced treatment trains and/or natural engineered treatment, potable reuse systems can provide protection from trace organic contaminants comparable to what the public experiences in many drinking water supplies today" (2012, pg. 5). Po et al. (2012) contend that expert risk perceptions are different from those of the general public. A layperson will determine risk through a broader context influenced by their interdependent social and cultural environment, while experts determine risk through a calculation of probability (Fielding & Roiko, 2014; Ormerod & Scott, 2012; Po et al., 2012). These are legitimate concerns given that CECs are unregulated contaminants and little is known about the potential long-term health risks (Kennedy/Jenks Consultants, 2013). Fielding and Roiko (2014) argue that although experts and laypeople understand probabilities differently, it is important to explore the effectiveness of providing information about levels of contaminants to the public. Alternatively, Ormerod and Scott (2012) focus on how the public's perception of risk reflects the level of trust in the institutions and authorities managing urban water and implementing potable reuse.

Public trust in water authorities is considered one of the principal factors shaping public acceptance in regards to water reuse (Dolnicar & Schäfer, 2009; Hartley, 2006;

Ishii et al. 2015; Marks, 2006; Ormerod & Scott, 2012; Po et al., 2003; Ross et al., 2014). Ormerod and Scott (2012) performed a Chi-square test of independence to examine the influence of trust in various sources of information (regulators, academics or water utilities) on an individual's willingness to drink reclaimed water. They found that the public's willingness to drink reclaimed water was highly influenced by the level of trust in institutions responsible for local water development. Given the strong indication that risk perceptions of potable reuse and trust in water authorities are both very influential aspects of public acceptance of potable reuse, Ross et al. (2014) developed a model of trust, risk perceptions and acceptance. They found that higher levels of trust in authorities are associated with lower perceptions of risk and a higher level of acceptance.

The factors that influence public perceptions of potable reuse are varied depending on the social and cultural environment. Over time, the public has become more comfortable with recycled water used closer to the body, and several water utilities have successfully implemented indirect potable reuse, such as Orange County's Groundwater Replenishment System. However, there has been little research into how environmental factors such as drought and climate change impact public perceptions of potable reuse. Examining public attitudes toward and knowledge of environmental issues, as well as perceptions of potable reuse, will shed light on how environmental change influences perceptions of potable reuse.

Socio-Demographic Factors

Studies of perceptions of potable reuse have tried to identify patterns in the opinions linked to certain demographics (Baumann, 1983; Dolnicar & Schäfer, 2009;

Friedler et al., 2006; Hartley, 2006; Po et al., 2012). By investigating likely accepters and rejecters of potable reuse, scholars hope to better understand what individual characteristics influence these perceptions and attitudes. For example, research shows that the more educated a person is about potable water reuse, the more accepting they are toward incorporating recycled water into their community's water portfolio (Baumann, 1983; Dolnichar & Schäfer, 2009).

A general lack of knowledge about alternative water supply options is a significant factor that negatively sways perceptions of potable reuse (Dolnicar & Schäfer, 2009). Dolnicar and Schäfer (2009) claim that historically, general knowledge about desalinated and recycled water has been very low. One of the earlier studies on perceptions of water reuse found that an individual's reaction to wastewater reuse was dependent on their knowledge and past experience with water reuse (Bauman, 1983). This early research also established that general level of education is positively correlated with acceptance of water reuse (Baumann, 1983). Baumann (1983) discovered that "the more formal the education, the higher the probability of the person's receptivity to using renovated wastewater" (pg. 81). Dolnicar and Schäfer (2009) also found that level of education played a role in an individual's acceptance of potable reuse: "The single personal characteristic found consistently over several studies to be related to stated acceptance levels of recycled water is education, followed by age, and knowledge about reuse, then income and gender" (pg. 889). However, a study conducted in Israel by Friedler et al. (2006) did not corroborate the correlation between level of education and higher acceptance of potable reuse. Friedler et al. (2006) surveyed 256 individuals in an

Israeli city to determine how the urban Israeli public felt toward various water reuses. This study expected to find a slight bias in their results due to higher percentage of educated people in the sample, but found no such correlation. Instead it found a slight correlation between age and level of support for water reuse.

Age is one of the most unpredictable variables correlated with acceptance of potable reuse. Some studies have found that older individuals are more likely to accept potable reuse (Friedler et al., 2006; Dolnicar & Schäfer, 2009), while others have found older individuals less likely to accept potable reuse (Bruvold, 1974; Millan et al. 2015; Po et al., 2012). Dolnicar and Schäfer (2009) found the average age of their "strong accepters group" for recycled water was 45.3 years old. Conversely, Millan et al. (2015) found that Santa Clara and San Diego respondents from 18-29 years of age were more supportive of potable reuse and that support declined with age.

Although age is not consistently correlated with acceptance or non-acceptance of potable reuse, sex and gender are more consistent influences. Women tend to be less comfortable than men with the idea of potable reuse (Po et al., 2012; Dolnicar & Schäfer, 2009; Millan et al., 2015; Tchobanoglous et al., 2015); indeed, Dolnicar and Schäfer (2009) found that across all their "strong accepter groups," men were consistently more heavily represented than women. Millan et al. (2015) surveyed Santa Clara and San Diego residents on their attitudes toward potable reuse and found that women were less likely than men to accept potable reuse and expressed more concerns related to health issues associated with potable reuse.

Overall, demographics are an inconsistent predictor of opinion on potable reuse. Po et al. (2003) argue that demographics alone cannot explain differences in the perceptions and acceptance of water reuse. However, the level of education and the type of educational background of individuals do seem to hold explanatory power. Examining the relationship between the level and category of academic discipline and the perception of potable reuse could reveal whether different types of academic study influence perceptions. Every community has a unique social fabric, including demographic factors that play a role in identifying whether or not a community is accepting of potable reuse. Identifying groups who may be more opposed to potable reuse than others is critical for water managers and utilities when proposing a potable reuse project. The next section of this paper will review research that focuses on public outreach and education in fostering public acceptance of potable reuse.

Fostering Public Acceptance

Recent research on potable reuse projects has moved beyond examining the factors that shape individuals' perceptions to explore how best to promote water reuse projects to achieve greater public acceptance (Fielding & Roiko, 2014). This body of research emphasizes public involvement through outreach, transparent communication, and education. Acknowledging the uniqueness of each situation, public utilities and local authorities must first understand the community and its concerns, identify the critical stakeholders, and design a community outreach plan that will foster trust, transparency and understanding.

Public outreach is listed as one of the three principal components of a potable reuse program in *Framework for Direct Potable Reuse,* and is essential for increasing public support (Tchobanoglous et al., 2015). Although public outreach and involvement can take significant time and effort, they have been shown to create the most sustainable and successful outcomes (Hartley, 2006; USEPA, 2012). Mark (2006) explains that the consistent theme in sustainable outcomes for water reuse is public involvement and public acceptance. Sometimes this means that potable reuse is not the best option for a community, but giving the public a choice in the matter makes whatever alternative reuse project they choose more sustainable.

Marks (2006) suggests that public involvement is not solely a means to push a potable reuse agenda; public involvement helps “to arrive at a sustainable outcome, not the acceptance of a system preferred by its proponents” (pg. 145). Though the best path forward for some communities is potable reuse, it can take a very long time to get the public to realize this on their own. “Experience has shown that public perception and support of potable reuse can be increased within a community through proactive, appropriate, and consistent outreach” (Tchobanoglous et al., 2015, pg. 121). The importance of public outreach is clearly illustrated by comparing San Diego’s failure at implementing potable reuse to Orange County’s success (Sedlak, 2014). Sedlak (2014) found that Orange County’s public outreach contributed greatly to continued public acceptance, while San Diego’s outreach attempts came much later in the process and the project failed due to public backlash. Not only did San Diego’s potable reuse project fail to involve the public early enough, the communication plan lacked transparency, making it seem as though the utility was hiding something from the public. When the public found out that one of the drivers of the San Diego Water Repurification Project was the need to reduce effluent discharge, they argued that the local water agency was channeling the wastewater for potable reuse to a lower income community, creating an environmental justice issue (Bridgeman, 2004; Po et al, 2003; Sedlak, 2014). San Vincent Reservoir was the only reservoir found to accommodate the San Deigo potable reuse project, however it was also perceived as the drinking water source for the southern portion of San Diego that is predominatly low income and African American (Hartley, 2006). Hartley (2006) explained that the San Vincent Reservoir supplies drinking water to all economic and racial demographics, while Po el al. (2003) argue that the opposition was fueled by political campaigns at the time. Nonetheless, the lack of early public involvement and transparency created suspicion and mistrust of the San Diego water authority.

Hartley (2006) looked at public perceptions and participation in water reuse projects and found that building and maintaining trust were critical themes in support of urban water management. In order to build trust, the organization must effectively engage the public by establishing a well-organized and effective communication plan (USEPA 2012; Fielding & Roiko, 2014; Hartley, 2006; Khan & Gerrard, 2005; National Research Council, 2012). "Organizations should demonstrate genuine commitment throughout the organization to engage and hear the public and take its concerns seriously" (Hartley, 2006, pg. 124). Khan and Gerrard (2005) explain that communication is a complex two-way process where information needs to be "delivered, received, interpreted and responded to" (pg. 355). This kind of two-way communication promotes understanding on both sides. Not only does the public gain a clearer understanding of the recycled water project, but the public utility also gains a greater understanding of public concerns and priorities.

Redwood City, California provides another example of a recycled water project that was delayed due to the lack of public outreach and acceptance, even though it was not intended for potable reuse (Nation Research Council, 2012; Sedlak, 2014). In the early 2000s Redwood City decided to implement water conservation, reclamation and reuse in order to meet its growing urban water demand (National Research Council, 2012). In 2002 the city presented the completed environmental impact review (EIR) for reclaimed water use to irrigate parks, yards, schools. Only two individuals showed up to the public hearing (National Research Council, 2012), but they formed a coalition objecting to the use of reclaimed water and used the Internet and social media to build opposition to the project (National Research Council, 2012). The project was delayed until the city and project opponents could come to an agreement on the importance of using reclaimed water to supplement their water demand.

Research Gaps

Research on perceptions of potable reuse consistently demonstrates that greater knowledge of water recycling (Baumann, 1983; Dolnicar & Schäfer, 2009) and early involvement in the planning and decision process greatly increase public support (Bischel et al. 2012; Hartley, 2006; Marks, 2006; Millan et al., 2015; Ross et al., 2014; Tchobanoglous et al., 2015; Tennyson et al., 2015; USEPA, 2012). Research also clearly indicates visceral aversion to water reuse, risk perception and lack of trust in local authorities as factors that most significantly impact an individual's perception of potable reuse (Dolnicar & Schäfer, 2009; Friedler et al. 2006; Meehan et al., 2013; Ormerod & Scott, 2012; Po et al., 2003). However, the social demographics of likely acceptors and non-acceptors are not consistent and display differences depending on where the study takes place (Dolnicar & Schäfer, 2009; Friedler et al., 2006; Hartley, 2006; Ishii et al., 2015; Po et al., 2003).

There is a lack of research on attitudes toward potable reuse in the San Francisco Bay Area, which is experiencing water stress due to population growth, extended drought and impacts of climate change. Additionally, there is an absence of research on the influence of these environmental factors on public perceptions. As water utilities are driven to find ways to diversify drinking water supply, exploring public awareness and concern regarding these environmental factors can provide valuable insight into their influence on perception of potable reuse as a drinking water solution.

There is also a lack of specific research on the younger generation's perceptions of potable reuse. The next generation of environmental stewards will be planning, voting and deciding on projects for the future water supply. According to a report by San Francisco Bay Area Planning and Urban Research Association (SPUR) "plans and projects are only as strong as the public's support allows" (2013, pg. 35). This is especially true in regards to projects and plans for potable reuse. Research focused on the opinions of younger residents will help provide information for planning the future water supply and management.

Focusing on college students for this study also permits examination of the influence of academic major on opinions about potable reuse. Millan et al. (2015) found that the youngest voters are more comfortable with DPR; support increased with level of education, but highly educated voters were also opposed. An examination into the relationship between the academic background of the young educated population and their attitudes toward potable reuse will be helpful. Key stakeholders for public outreach for potable reuse projects include water supply and wastewater associations, academic and engineering-related associations and leaders, environmental groups and leaders, and health care industry members (Millan et al., 2015). However, so far, there isn't a study that examines the influence of academic background on opinions about potable reuse. Studying students' opinions regarding potable reuse according to their academic major will shed light on how scholastic concentration influences attitudes toward potable reuse.

This study will address these gaps in the literature by focusing on SF State students from a variety of academic majors. Assessing their knowledge of and concerns about the current water system and various environmental factors, as well as their perceptions of potable reuse, may uncover relationships between these elements that have not yet been studied.

Methods

The aim of this research is to explore how attitudes and opinions towards potable reuse vary among college students depending on their academic major, as well as their understanding of and concern about tap water networks and drought conditions. In order to explore this research question, students at SF State were surveyed using an online questionnaire. Questionnaires are the most widely used method of developing a representative generalization about attitudes and characteristics of a large population (Check & Schutt, 2011). The Institutional Review Board (IRB) determined this study was exempt from regulatory oversight and did not require further review due to the preservation of participants' anonymity by an electronic hyperlink (Survey Platform, 2016). The process of survey design, survey distribution, selection of survey participants, and analysis of data are explained in further detail below.

Procedure

The online questionnaire was open from May 12th to June 8, 2016. Random sampling was employed by distributing the online survey to all SF State departments and requesting they email it to their student list serves, allowing students to voluntarily participate.

A survey pre-test was conducted using graduate students in the Geography Department to evaluate question structure and clarity, as well as to ascertain the average length of time that it took to complete the survey. According to Hay (2005), a pre-test is helpful in testing the survey design, appropriateness of the audience, and whether the questions provide the answers that the study is looking for. The pre-test showed that the survey took an average of 11 minutes to complete. After the pre-test, several questions found to be unproductive in assessing participants' knowledge of and opinions about potable reuse were omitted, and replaced with specific questions on opinions about potable reuse that provided more targeted information for analysis.

Once the survey was ready to distribute, the survey hyperlink was emailed and displayed on various social media websites with a brief explanation of the study. The email was sent to all thirty-seven SF State departments, as well as seventeen student organizations/clubs, both lists provided by the Campus Academic Resource Program (CARP). The survey authorized the "Prevent Ballot Box Stuffing" options to prevent students from participating more than once, by placing a cookie in the respondent's browser when they started the survey (Survey Platform, 2016). Not all departments agreed to distribute the online survey to their student listserves, therefore the social media websites OrgSync and Facebook were employed to recruit further participation. OrgSync is a social media platform that helps connect organizations and their members for communication and collaboration. This study was able to distribute the survey to all SF State students who use OrgSync. Facebook was used to display the survey hyperlink on SF State club or department "pages" that allowed public postings. The total number of students who received an invitation to participate cannot be determined due to the nature of this survey distribution. The total student population at SF State is approximately 30,000, and by using various methods of distribution this study aimed to obtain approximately 170 participants, which allows a 7.5 margin of error.

Participants

The students of SF State were chosen to be the participants of this survey because university students have been inadequately examined in previous studies on the perceptions of potable reuse. University students tend to be younger and more educated than the general population. According to 2015-2016 SF State student demographic information, the student body has more female students (57.1%) than male (42.9%), and most of the student body originates from California (91%) (SF State Facts, 2016). The average student is 23 years old and most are enrolled in an undergraduate program (88%). The largest colleges are Liberal & Creative Arts (29.2%), followed by Health & Social Studies (24.3%), Business (22.6%) and Science and Engineering (17.9%).

Though some studies (Hartley, 2006; Po el al., 2012; Dolincar & Schäfer, 2009) show that an educated younger population tends to be more accepting of potable reuse, there has yet to be a study focused on the opinions of college students. While Millan et al. (2015) state that educational institutions and leaders have influential opinions in the community, they neglect to address the implications of students' opinions and influence on their communities' future. Examining the opinions of the SF State students will provide insight into the attitudes of the next generation of voters and policy makers and how they feel about recycled wastewater as a potential drinking water source.

Survey Design

The online survey was designed using Qualtrics Survey Software to gather data on SF State students' knowledge, concern and perceptions about their tap water systems and potable reuse. The survey was organized into four main topics: knowledge and concerns about tap water systems, knowledge and concerns about California's drought conditions, knowledge and opinions about potable reuse, and individual demographic information. The data from these four sections were cross-tabulated to analyze relationships and correlations.

The first section of questions focused on subjects' knowledge of their current tap water sources, including where they believe their tap water comes from, what they know about its treatment and where they think it goes after being used. This section was designed to evaluate the attitudes and perceptions about potable reuse among students depending on their level of knowledge about tap water. In order to check the accuracy of the individual responses regarding their tap water system, test questions were posed. For example, if the participant responded "yes," to the question, "Do you know where the main source of your tap water comes from?" they were asked to "select the water source that best fits your main tap water supply" from a series of choices for the particular county where they stated they currently live. Similar follow-up questions were used after asking "Do you know what kind of treatment(s) your tap water goes through to make it drinkable?" and "Do you know what happens to your wastewater (shower, toilet, sinks, etc.) after it goes down the drain?" to confirm the participants' knowledge of their current tap water and sewage systems.

Multiple-choice questions were asked to assess respondents' behavior and opinions regarding tap water, to see whether there is a correlation between their behavior and their opinions toward potable reuse. An example of a behavioral question is, "Do you drink tap water at home? and if not, then why?" Likert Scale questions were used to measure concerns about tap water using a five-point range from “very concerned” to “not at all concerned.” The scale was used to gauge how concerned the students were about the quantity and quality of their tap water, conditions of tap water infrastructure (such as pipes and dams) and water treatment standards. These questions on behavior and concerns were used to assess the hypothesis that behavior and concerns about tap water positively correlate with opinions about recycling water for drinking purposes. In other words, favorable attitudes toward potable reuse are more likely to be expressed by students who currently drink tap water.

The second section of questions addressed concern and knowledge about the current drought in California. These questions aimed to assess whether SF State students are aware of the severity of the drought in California and whether they are concerned about it. The same five- point Likert Scale of “very concerned” to “not at all concerned” was used to ascertain “How concerned are you about the current drought in California?” This section also contained two questions to assess whether students believed that recent winter storms had alleviated drought conditions, and if they believed droughts would continue to increase in severity in the future. The questions were designed to evaluate the hypothesis that favorable attitudes toward potable reuse are more likely to be expressed by students who are knowledgeable and concerned about the California drought.

The next section of questions focused on general knowledge and attitudes about potable reuse. In order to evaluate respondents’ level of knowledge about potable reuse, the survey asked whether they were familiar with the definitions of potable reuse and advanced treated water. For both questions they are given the options of choosing, “yes,” "no," or "somewhat." Following these two initial questions, the survey asked if they are familiar with or aware of any current potable reuse project in California, and if so, which one(s). These questions aim to assess how aware they are of potable reuse projects, with the hypothesis that favorable attitudes toward potable reuse are more likely to be expressed by students who are knowledgeable about existing potable reuse projects.

The two most important questions of this study were "How likely are you to support recycled water for drinking purposes (potable reuse) in your municipality?" and, "How likely are you to drink recycled water treated to drinking (potable) standards?" These questions were used to evaluate respondents' level of support and acceptance of potable reuse. These two questions were cross-tabulated to assess the correlation between level of acceptance for potable reuse, water-related behavior and concerns, and awareness of potable reuse projects. For each of these questions, a five point Likert Scale was used, ranging from "very likely" to "not likely at all." If the participant answered either "somewhat unlikely" or "not likely at all," then they were prompted with multiple choice questions to answer why they were less likely to support and/or drink recycled water for drinking purposes. Those participants that answered either "very likely" or "likely," to either question were prompted to answer multiple-choice questions on why they would be likely to support or drink recycled water treated to drinking standards. This series of questions on the likelihood of supporting or consuming recycled water was designed to assess the level of acceptance of potable reuse by SF State students.

Lastly, the survey requested general demographic information including gender, age, ethnic identity, academic grade level, and academic major at SF State. As noted in the literature, demographic factors such as gender and age, are inconsistent variables in their support of potable reuse. Demographic data were collected to ascertain who took the survey, and whether or not it is a representative sample of the SF State population based on the 2015-2016 SF State Student Enrollment data (SF State Facts, 2016). This data also offered the opportunity to evaluate possible correlations between the demographics categories and support for or knowledge of potable reuse. In particular, participants' academic major was used to test the hypothesis that students in environmentally-focused majors will be more likely to express favorable attitudes toward potable reuse than students in health-related majors. For example, academic majors involving public health, nursing, or early child development will likely not support potable reuse. On the other hand, academic majors involved in engineering, urban studies and planning, and resource management are likely to support potable reuse.

Methods of Analysis

The results of this survey were analyzed using both qualitative and quantitative methods. Qualitative analysis of the open-ended questions involved a process of open coding, scoring the data for themes, ideas and concepts that can be easily compared and analyzed for patterns in responses. The responses to the open ended questions for this survey were coded based on repetition of words or phrases and categorized based on their similarity.

A quantitative method of analysis employed cross tabulation, also known as contingency table analysis (Cross Tabulation Analysis, 2011). Cross tabulation analysis provides information on the relationship between two categorical variables by recording the frequency of respondents that have the characteristics described in the cells of the table (Cross Tabulation Analysis, 2011). The statistical significance of these associations was tested with Chi-square analysis (Cross Tabulation Analysis, 2011). Chi-square is the primary statistical tool used in cross tabulation, which tests the level of independence of the variables along with associated probability represented in p-value (Cross Tabulation Analysis, 2011). The level of significance in this study was a p-value < .05, indicating a low chance of being independent, thus a high probability of association. Cross tabulation analysis will test the following hypotheses:

1. Perceptions of potable reuse will vary with the student's academic major. Students in environmentally-focused majors will be more likely to express favorable attitudes toward potable reuse than students in health-related majors.
2. Favorable attitudes toward potable reuse are more likely to be expressed by students who currently drink tap water.
3. Favorable attitudes toward potable reuse are more likely to be expressed by students who are knowledgeable and concerned about the California drought.
4. Favorable attitudes toward potable reuse are more likely to be expressed by students who are knowledgeable about existing potable reuse projects.

When interpreting statistical associations, it is important to acknowledge the difference between correlation and causation. Defining the statistical correlation in the data through Chi square analysis of two nominal variables does not conclude causality. The Chi-square analysis ((Observed Value – Expected Value)2 / (Expected Value)) indicates a degree of relationship between variables. Examining correlations in this study will explore associations and relationships.

Utilizing both qualitative and quantitative methods, this study aims to explore the research questions through careful comparison and correlation analysis. Analyzing the data in this way will demonstrate how college students in the Bay Area feel toward potable reuse, and whether there is a correlation between their knowledge, behaviors, and academic major.

Results

A total of 174 students participated and 163 students (n=163) completed the survey (Table 1). The survey distribution began two weeks before the end of the spring semester on May 12, 2016, and closed one week after school was dismissed for summer break on June 8^{th}, 2016. The majority of students took the survey during the week of final exams. The survey was closed due to a rapid decline in participation after final exams were finished and school was dismissed for summer break.

A majority of participants (62%) identified themselves as female, followed by male (33%) and non-binary gender (5%). The age of students ranged from 18-55 years, with an average age of 28. The majority identified as White Non-Latino (56%), followed by two or more races (12%) and Asian (10%). Almost half (48%) of the participants live in the City and County of San Francisco, followed by Alameda County (26%) and San Mateo County (10%). Six of the participants lived outside of the nine-counties in San Francisco Bay Area, and none lived in Marin or Solano County. Approximately three-quarters (76%) stated that they grew up in the San Francisco Bay Area or elsewhere in California, very similar to the place of origin of the SF State population as a whole (Table 1).

Participants were nearly evenly split between undergraduate (47%), and graduate students (52%). The bulk of the participants were majors in departments within the colleges of Liberal & Creative Arts (40%) and Science & Engineering (40%), followed by the college of Health & Social Studies (20%). There were no participants from the other colleges at SF State (Table 1).

Based on the total SF State student population (30,256) in 2015-2016 enrollment statistics, the survey sample size (n=163) represents a 7.66 margin of error with a 95% confidence level and 50% level of accuracy. Table 1 displays the comparisons of the demographic structure of SF State's student body with this survey's sample. The main differences are the enrollment level, participants from each college and ethnicity.

Table 1: Demographic distribution of the survey sample and the SF State student population.

	Demographic Categories	SF State Enrollment 2015-2016 (30,256)	Survey Sample May-June 2016 (n =163)
Enrollment Type	Undergraduate Graduate	88.6% 11.4%	47.24% 52.15%
Gender	Female Male Non-binary	57.1 % 42.9% NA	61.96% 32.52% 5.52%
Ethnicity	African American American Indian/Alaskan Native Asian Chicano, Mexican American Latino Pacific Islander Two or More Races White Non-Latino	5.2% .2% 32.4% 21.8% 11.5% .5% 6.2% 22.1%	2.63% .66% 9.87% 3.94% 7.24% 0% 11.84% 55.92%
Origins	Bay Area California Other States Other Country	NA 91% 1.3% 5.6%	38.04% 38.04% 14.11% 9.82%
Age	Average	23.4 years	28 years
Degrees Conferred by College 2014-2015*	Business Education Ethnic Studies Health & Social Studies Interdisciplinary Studies Liberal & Creative Arts Science & Engineering	22.6% 4% 1.2% 24.3% 0% 29.2% 17.9%	0% 0% 0% 20% 0% 40% 40%
* This category cannot be exactly compared because the surveys collected data from students currently enrolled and SF State's degrees conferred are students who graduated in 2015.			

Behavior and Knowledge of Tap Water

The first questions in the survey assess the hypotheses that participants are more likely to support potable reuse projects and drink recycled water if they currently drink tap water, and also if they have an accurate knowledge of their tap water system. The majority of participants drink tap water at home (86%) and if they don't, it is mainly because they think it does not smell or taste good. Contra Costa County has the highest percentage of participants (63%) that said they do not drink tap water at home, while Sonoma County (100%), San Mateo County (94%), San Francisco and Alameda County (89%) had the highest percentage of participants who drink tap water at home (Table 2).

The bulk of participants (58%) knew where their drinking water comes from, however most of them (84%) were either unsure of or did not know what kind of treatment their tap water goes through to make it potable.

Table 2: Cross tabulation displaying the frequency of respondents who drink or do not drink tap water at home and what county they currently live in the Bay Area.

	Do you drink tap water at home?		
Where do you currently live?	**Yes**	**No**	Total
Alameda County	39	5	44
Contra Costa County	3	5	8
Marin County	0	0	0
Napa County	2	1	3
San Francisco County	74	9	83
San Mateo County	18	1	19
Santa Clara County	4	2	6
Solano County	0	0	0
Sonoma County	3	0	3
Other	4	2	6
Total	147	25	172
p-value 0.01			

To further assess the relationship between behavior and knowledge of tap water origins and opinion or attitude toward potable reuse, a Chi-square test was performed with cross tabulation (Table 3). The first question regarding drinking tap water was cross-tabulated with two Likert Scale questions regarding opinions of potable reuse. Table 3 shows that of the 141 participants who said they drink tap water at home, 54 (38%) said they are "very likely" to support recycled water for drinking purposes and 43 (30%) said they are "very likely" to drink recycled water for drinking purposes. On the other hand, the participants who said they do not drink tap water at home (14%) were most likely not to support potable reuse, nor to be willing to drink recycled water. The correlation analysis from this data shows a significant relationship (p value < .01) between drinking tap water at home and support for potable reuse/drinking recycled water treated to potable standards.

Table 3: Cross tabulation displaying the frequency of respondents who drink do or do not drink tap water at home and their level of support on a scale of 1 (very likely) to 5 (very unlikely) for recycled water for drinking purposes in their municipality and the likelihood of drinking recycled water.

	Do you drink tap water at home?			
		Yes	**No**	**Total**
How likely are you to *support* recycled water for drinking purposes (potable reuse) in your municipality?	**Very likely**	54	3	57
	Likely	50	5	54
	Neutral	28	7	35
	Unlikely	7	6	13
	Very unlikely	2	2	4
	Total	141	23	163
p-value 0.00				
How likely are you to *drink* recycled wastewater treated to drinking (potable) standards?	**Very likely**	43	2	45
	Likely	53	2	54
	Neutral	32	9	41
	Unlikely	9	6	15
	Very unlikely	4	4	8
	Total	141	23	163
p-value 0.00				

Concerns About Tap Water and Drought

The second section of questions was aimed at assessing the hypothesis that participants who are more concerned with issues regarding tap water systems as well as the current California drought, are more likely to accept potable reuse projects and to drink recycled water.

To evaluate concerns regarding tap water, participants were asked to rate their level of concern for six issues. Most of the participants stated they were "Concerned" about all issues listed, and in particular the state of the water infrastructure (36%) and the quantity of drinking water supply available (33%). In regards to the issue of tap water quality, approximately one quarter (26%) of participants stated they were "not at all concerned" with the quality of their tap water.

To further explore concern about the quantity of tap water available, students were asked to rate their level of concern about the current drought in California (Table 4). Cross tabulation was conducted to further examine the statistical correlation between concerns with tap water and drought conditions with support for potable reuse. In regards to the level of concern for the California drought, 85 (52%) of the participants who are "very concerned," 36 (42%) are also "very likely" to support recycled water in their municipality, and 30 (66%) are "very likely" to drink recycled water (Table 4). The statistical analysis shows a significant relationship (p-value < .01) between concern about the drought and support of potable reuse, as well as concern about the drought and likelihood of drinking recycled water (p-value < .04).

Similarly, a strong correlation (p-value < .01) was found between participants who believe droughts will increase in California in the future and the likelihood of support for potable reuse. Of the 135 participants who believe droughts in California will increase in severity, 51 (38%) are "very likely" to support potable recycled water for drinking purposes and 39 (28%) are "very likely" to drink recycled water.

Table 4: Cross tabulation displaying the frequency of respondents level of concern on a scale from 1 (very concerned) to 5 (not at all concerned) and their level of support on a scale of 1 (very likely) to 5 (very unlikely) for recycled water for drinking purposes in their municipality and the likelihood of drinking recycled water.

		How concerned are you about the current drought in California?					
		Very concerned	**Concerned**	**Neutral**	**Somewhat concerned**	**Not at all concerned**	Total
How likely are you to *support* recycled water for drinking purposes (potable reuse) in your municipality?	**Very likely**	36	16	4	1	0	57
	Likely	31	22	0	2	0	54
	Neutral	13	17	1	2	2	35
	Unlikely	4	8	1	0	0	13
	Very unlikely	1	2	0	0	1	4
	Total	85	65	6	5	3	163
p-value 0.01							
How likely are you to *drink* recycled wastewater treated to drinking (potable) standards?	**Very likely**	30	11	3	1	0	45
	Likely	32	20	0	2	1	54
	Neutral	17	21	2	0	1	41
	Unlikely	5	8	1	1	0	15
	Very unlikely	1	5	0	1	1	8
	Total	85	65	6	5	3	163
p-value 0.04							

Knowledge and Attitude Toward Potable Reuse

The third section of questions was meant to test the hypothesis that the more aware participants are of potable reuse projects, the more likely they will be to support potable reuse projects in their municipality. Assessing participants' familiarity with technical definitions regarding potable reuse, awareness of current potable reuse projects, and opinions regarding potable reuse tested this hypothesis.

Table 5: Students response (n=163) regarding level of support on a scale of 1 (very likely) to 5 (very unlikely) for recycled water for drinking purposes in their municipality and the likelihood of drinking recycled water.

How likely are you to support recycled water for drinking purposes (potable reuse) in your municipality?		
Answer	**%**	**Count**
Very Likely	35.97%	57
Likely	33.13%	54
Neutral	21.47%	35
Unlikely	7.98%	13
Very Unlikely	2.45%	4
Total	100%	163
How likely are you to drink recycled wastewater treated to drinking (potable) standards?		
Very Likely	27.61%	45
Likely	33.13%	54
Neutral	25.15%	41
Unlikely	9.2%	15
Very Unlikely	4.91%	8
Total	100%	163

After reading a definition of potable reuse and advanced water treatment, 74% said they were familiar or somewhat familiar with the concept of potable reuse, and 60% said they were familiar or somewhat familiar with advanced treatment for potable reuse. A majority (82%) were not aware of any current potable reuse projects in California or the US. Those who were aware of potable reuse projects listed a variety of answers that were coded into five projects or project areas, including, Orange County project (17%), San Diego project (28%), Los Angeles project (7%), non-potable reuse projects (24%), and other answers (24%) that could not be efficiently coded.

The majority (68%) of participants were “very likely” or “likely” to support recycled water for drinking purposes in their municipality (Table 5). The questionnaire also asked how likely they would be to drink recycled wastewater treated to drinking standards. A majority (61%) of participants stated they were “very likely” or “likely” to drink recycled water (Table 5). The main reasons selected for not supporting potable reuse or drinking recycled water was “I don’t know enough about it,” (35%), “Unsafe/unclean/health concerns” (26%), and “I don’t trust the municipality to properly manage the treatment and distribution of it” (17%). Three participants chose “Other” and described their reason for not being likely to support potable reuse or drinking recycled water as follows:

> —*“Drug contents, other filterable contaminants”*
>
> —*“More than anything, I don't know enough about it, however, if I were informed, I'm not sure I'd trust the information if it were given by the government or other establishment networks. Additionally, I feel that there are other water resources and process, such as fracking, that can be lessened.”*
>
> —*“Can’t we just shower and flush our toilets with it?”*

The first open-ended response could be categorized as “Unsafe/unclean/health concerns,” but the second response suggests several reasons to be reluctant to support water recycling or drink recycled water, including lack of knowledge, lack of trust, and a preference for alternative water conservation methods. The third response shares a preference for alternative, non-potable options for water recycling.

The main reasons selected for supporting water recycling or drinking recycled water were “Water shortage and drought” (38%), “It’s less energy intensive than other water supply options like desalination or new dams” (24%) and “The water is safe and clean to drink” (20%). Four participants choose “Other” and offered the following reasons:

—*“Advancements in technology”*

—*“Even if it's not safe to drink, doing it helps future generations. Gotta start somewhere.”*

—*“I trust it, and it is the easier and cheaper method”*

—*“All of the above, I'd just have to have a mental wrestling match with my intense germaphobia”*

These open-ended responses suggest trust in the advances in technology, trust in treatment methods, and willingness to support potable reuse in the interest of future generations. The last response admits that they would have a hard time with the concept of recycling water, but agrees with all the options to support it. This indicates that there is a willingness to support potable reuse even though there is still a visceral disgust and a lack of trust in the technology to safely remove all contaminant from the wastewater.

Cross tabulation to examine the correlation between familiarity with/awareness of potable reuse and support for water recycling yielded no statistically significant results (Table 6). The majority of the participants (82%) indicated that they were not aware of any current potable reuse project in California or the US. Cross tabulating these responses with the likelihood of supporting or drinking recycled water for drinking purposes rejected the hypothesis that awareness of potable reuse project and support for potable reuse was positively correlated.

Table 6: Cross tabulation displaying the frequency of respondents familiarity or awareness of current potable reuse projects and their level support on a scale of 1 (very likely) to 5 (very unlikely) for recycled water for drinking purposes in their municipality and the likelihood of drink recycled water.

		Are you familiar or aware of any current potable reuse projects in California or the US?		
		Yes	**No**	Total
How likely are you to *support* recycled water for drinking purposes (potable reuse) in your municipality?	**Very likely**	14	43	57
	Likely	8	47	54
	Neutral	2	33	35
	Unlikely	3	10	13
	Very unlikely	2	2	4
	Total	29	135	163
p-value 0.07				
How likely are you to *drink* recycled wastewater treated to drinking (potable) standards?	**Very likely**	12	33	45
	Likely	8	47	54
	Neutral	5	36	41
	Unlikely	2	13	15
	Very unlikely	2	6	8
	Total	29	135	163
p-value 0.38				

Demographics and Perception of Potable Reuse

The demographic information from the survey data is displayed in Table 1, including academic major, grade level, age, gender, ethnicity and place or origin. Each of the demographic variables was evaluated for possible correlation with support for potable reuse.

The survey asked participants to indicate their academic major in order to examine the hypothesis that attitudes and perceptions about potable reuse relate to the academic major of the participant. The departments with the highest number of participants were Geography & Environment (28%), English (23%), Environmental Studies (12%), Anthropology (11%), Liberal Arts (7%) and Health Education (6%) (Table 7).

Table 7: Distribution of participants according to academic major.

Academic Major	**%**	**Count**
Geography & Environment	27.78%	45
English	22.84%	37
Environmental Studies	12.96%	21
Anthropology	11.11%	18
Liberal Arts	6.79%	11
Health Education	6.17%	10
Biology	2.47%	4
Psychology	1.85%	3
Other	1.85%	3
Urban Studies and Planning	1.23%	2
Engineering	1.23%	2
Child and Adolescent Development	0.62%	1
Marine Science	0.62%	1
Chemistry	0.62%	1
Philosophy	0.62%	1
Earth & Climate Science	0.62%	1
History	0.62%	1
Total	**100%**	**162**

Only the English and Geography majors were used to evaluate correlation between academic major and support for potable reuse because these offered a marked difference in academic discipline and curriculum. However, the correlation analysis did not show statistical significance (Table 8). The students majoring in Geography are presumably more likely to have taken academic courses on water resources and resource management, while students in the English department are presumably less likely to have taken such courses. Nevertheless, Geography and English students both showed strong support for potable reuse, with 24 (65%) English students and 30 (67%) Geography students stating they would be "likely" or "very likely" to support potable reuse (Table 8).

Table 8: Cross tabulation displaying the frequency of respondents according to academic major and their level of support on a scale of 1 (very likely) to 5 (very unlikely) for recycled water for drinking purposes in their municipality and the likelihood of drink recycled water.

		Academic Major		
		English	Geography & Environment	Total
How likely are you to *support* recycled water for drinking purposes (potable reuse) in your municipality?	Very likely	10	16	26
	Likely	14	14	28
	Neutral	6	10	16
	Unlikely	7	2	9
	Very Unlikely	0	3	3
	Total	37	45	82
p-value 0.11				
		English	Geography & Environment	Total
How likely are you to *drink* recycled wastewater treated to drinking (potable) standards?	Very likely	7	15	22
	Likely	13	11	24
	Neutral	11	12	23
	Unlikely	5	4	9
	Very Unlikely	1	3	4
	Total	37	45	82
p-value 0.48				

Students' academic level (undergraduate or graduate) did not show a statistical correlation with support of potable reuse. Both undergraduate and graduate students indicated their support, with 54 undergraduate students (70%) and 57 graduate students (67%) stating they would be "likely" or "very likely" to support potable reuse.

Although the question of ethnicity was an optional question in the survey, 152 participants responded, however no significant statistical correlation was found between ethnicity and support for potable reuse or likelihood to drink recycled water. In order to identify statistical correlation through cross tabulation, only the ethnicity categories with more than 5 participants were used for the analysis (Table 9). The ethnic categories of Pacific Islander (0) and American Indian, Alaskan Native (1) were eliminated because they had less than 5 participants, which can skew the Chi-square analysis.

Table 9: Cross tabulation displaying the frequency of respondents according to ethnic identity and their level of support on a scale of 1 (very likely) to 5 (very unlikely) for recycled water for drinking purposes in their municipality and the likelihood of drink recycled water.

		Ethnic Identity						
		Asian (including Filipino)	**Chicano, Mexican American**	**Latino**	**Two or more races**	**White Non-Latino**	**Other**	Total
How likely are you to *support* recycled water for drinking purposes (potable reuse) in your municipality?	**Very likely**	2	3	3	8	30	5	51
	Likely	6	0	4	4	35	2	51
	Neutral	5	2	4	6	13	2	32
	Unlikely	1	1	0	0	5	2	9
	Very unlikely	1	0	0	0	2	1	4
	Total	15	6	11	18	85	12	147
p-value 0.34								
How likely are you to *drink* recycled wastewater treated to drinking (potable) standards?	**Very likely**	2	2	0	6	26	4	40
	Likely	5	0	5	5	34	2	51
	Neutral	4	2	5	6	17	3	37
	Unlikely	1	2	1	1	5	2	12
	Very unlikely	3	0	0	0	3	1	7
	Total	15	6	11	18	85	12	147
p-value 0.09								

Age is not a consistant variable shown to predict support for potable reuse, and further demonstrated in this study that not find a statistical correlation between age and support for potable reuse. (Table 10). The analysis between gender and support of potable reuse did not yield a significant relationship, nor did the analysis of correlation between place of origin and support for potable reuse.

Table 10: Cross tabulation displaying the frequency of respondents according to age groups and their level of support on a scale of 1 (very likely) to 5 (very unlikely) for recycled water for drinking purposes in their municipality and the likelihood of drink recycled water.

		Age (years)						
		18-21	22-25	26-29	30-33	34-37	38 +	Total
How likely are you to *support* recycled water for drinking purposes (potable reuse) in your municipality?	Very likely	12	17	11	6	2	9	57
	Likely	8	15	14	8	5	4	54
	Neutral	7	12	5	3	1	5	33
	Unlikely	2	0	7	2	1	1	13
	Very Unlikely	2	1	0	1	0	0	4
	Total	31	45	37	20	9	19	161
p-value 0.37								
		18-21	22-25	26-29	30-33	34-37	38 +	Total
How likely are you to *drink* recycled wastewater treated to drinking (potable) standards?	Very likely	9	13	9	5	2	7	45
	Likely	8	17	12	9	4	4	54
	Neutral	8	11	10	1	2	7	39
	Unlikely	3	2	4	4	1	1	15
	Very Unlikely	3	2	2	1	0	0	8
	Total	31	45	37	20	9	19	161
p-value 0.77								

Discussion

The central findings of this study are that participants are more likely to support potable reuse and to drink recycled water if they already drink tap water at home, are concerned about the drought in California, and believe that droughts will continue to increase in severity. These findings contribute to the body of literature on public perceptions of potable reuse that considers trust in authorities, perceptions of risk, socio-demographic elements, and effective public outreach as factors that influence perceptions of potable reuse.

The strong correlation (p value < .05) found between drinking tap water at home and support for potable reuse confirms one of the hypotheses of this study. The high percentage of participants who drink tap water suggests a high level of trust in the local water authority. Saylor et al. (2011) found that those who drink tap water are generally more trusting that the government will safeguard the quality of tap water. The survey also found that the participants who do not drink tap water (14%) avoid it either because it doesn't taste good or doesn't smell right (39%), or they do not trust it is safe to drink (35%). This implies that besides one's opinion of taste and smell, trust is a critical factor in the decision to drink tap water. Ross et al. (2014) found that higher levels of trust in authorities are associated with lower perceptions of risk, thus increasing the level of acceptance. The correlation found in this study is not surprising, yet it demonstrates that students at SF State drink tap water and trust their local water authority, making them more likely to accept potable reuse.

However, SF State students reside in various counties in the Bay Area, which receive their drinking water from different sources. While some places such as San Francisco and Alameda County receive fairly pristine sources of drinking water from the Sierra Nevada, students who live in Contra Costa or Santa Clara County are subject to *de facto* reuse. While most participants in this study stated they drink tap water at home, Table 2 indicates that participants from Contra Costa and Santa Clara County had the highest percentage of individuals who do not drink tap water at home. This study also determined that 58% of particpants know where their drinking water is coming from, indicating that they understand the quality of their current drinkning water. These results indicates the individuals are more likely to drink tap water from higher quality sources of water from municipalities they trust.

A strong correlation (p value < .05) between a higher level of concern for the drought in California and support for potable reuse confirmed another hypotheses of this study. It was also determined that participants who believe that droughts will increase in severity in the future were also more likely to support potable reuse. The higher level of concern for the California drought implies heightened awareness and understanding of drought implications on the reliability of water resources. Individuals with a better grasp of drought implications are also more likely to modify their behavior to adapt to such conditions. A survey by Xylem Inc. (2016) found that 89% of Californians agree that the drought has made them more supportive of recycled water. Recognizing that droughts will continue in severity indicates an understanding of the implications of climate change for the geographic region of California. The effects of climate change are predicted to have a detrimental impact on water resources, pressing water managers to diversify their water resources and look toward alternative water sources.

In spite of the central findings of this study, some hypotheses were not confirmed by the survey results, including the correlation between support for potable reuse and students' academic major, as well as their awareness of other potable reuse projects in California. Assessing the correlations with academic major was an exploratory inquiry into whether educational programs had an influence on the perceptions of potable reuse. The lack of statistically significant correlation may have been due to the lack in variety of the academic departments that participated in the survey. This study anticipated that students in environmentally-focused majors would be more likely to express favorable attitudes toward potable reuse than students in health-related majors, however all the majors showed favorability towards potable reuse. To further explore this hypothesis in future research, selective stratified sampling is recommended to obtain an even portion of participants from a range of academic departments with contrasting curricula.

The lack of significant correlation (p value $> .05$) between awareness of and familiarity with current potable reuse projects and support for potable reuse projects was somewhat surprising since knowledge of or experience with potable reuse was found by other scholars to be a factor in influencing perceptions (Baumann, 1983; Dolnichar & Schäfer, 2009; Fielding & Roiko, 2014). Even though this study found that more than 82% of participants were unaware of or unfamiliar with other potable reuse projects, 67% of them said they would be "very likely" or "likely" to support potable reuse project in their local municipality. Fielding and Roiko (2014) claim that individuals sometimes lack the knowledge, time and interest to make decisions, therefore they trust the authorities or water agencies to make such decisions. Results from this study may imply a level of trust in the local water authorities, or it might suggest that the participants are not informed enough about potable reuse to make such a decision. Although the majority of participants expressed support for potable reuse, approximately a quarter of participants expressed neutrality. About 21% of participants selected “neutral” on the likeliness to support potable reuse project in their local municipality, and 25% on the likeliness of drinking recycled water treated to potable standards. The “neutral” response can be difficult to decipher without follow-up questions for those participants, but this study inferred that “neutral” is an undecided response, signifying neither support nor opposition. The frequency of the “neutral” response may indicate that the participants do not feel that are knowledgeable enough to have an opinon about potable reuse.

Although this study made no hypotheses associated with demographics other than academic major, cross tabulations were administered to explore potential correlations between demographics and attitudes of potable reuse, but no significant correlations were found. It is important to note that the survey sample was not a representaive sample of SF State, especially its ethnic diversity. The survey sample underrepresented all non-White ethnic categories (SF State Facts, 2016). According to Millan et al. (2015) communities of color and non-English speakers are less likely to support potable reuse. The study determined that various ethnic groups, or those from other countries, might have only had bottled water as a source of safe drinking water, leading some to mistrust tap water (Millan et al., 2015). It is difficult to determine if this is the case with students at SF State without further qualitative research, however the over-representation of the White Non-Latino/a demographic coupled with the stronger overall favorability of potable reuse may indicate that White Non-Latinos are more accepting of potable reuse.

The limitations of this study, including the method and time frame of data collection, the small sample size and the potential for self-selection bias may have had an effect on the results of this study. The timing of the survey distribution may have negatively impacted participation, but the distribution schedule was necessary due to the researcher's time constraints. Use of an electronic survey as the only method of data collection may have limited the number of participants and excluded individuals who lacked access to a computer or to the Internet. Employing other methods such as interviews and focus groups could provide a more comprehensive sample for the study. The method of survey distribution may have also introduced a self-selection bias: since the survey was voluntary, it is quite possible that individuals who already had an interest or opinion in wastewater reuse were more likely to participate than individuals with no previous experience or interest in the subject. Utilizing face-to-face or on-the-street surveys may have broadened the range of participants. These in-person methods of data collection and distribution were not employed during this study because they required an additional Institutional Review Board proposal that would have further delayed the overall study.

The participation biases may also have affected the overall results of this study. In regards to enrollment type, the bias may be rationalized by the fact that the survey was identified as work for a graduate-level thesis in geography, influencing fellow graduate student camaraderie in participation, or perhaps graduate students are more likely to take surveys. The over-representation of graduate students could also explain the older average age of respondents. The heavier participation by certain departments is likely due to the departments who chose to distribute the survey, as well as the level of interest of students in the survey.

Using this survey as a model, future studies can expand to other Universities, in order to gain a more substantial perspective on college student perceptions of potable reuse. Future studies using this survey would benefit from obtaining a larger sample size and a larger assortment of contrasting academic majors and ethnicities, and by starting the survey distribution earlier in the school year. Utilizing other methods of data collection such as focus groups and/or follow up interviews with some of the participants could also expand the opportunity for qualitative analysis to gain a more in-depth perspective as to why some of the students were more supportive of potable reuse than others.

Conclusion

As the population is predicted to grow and climate change is projected to constrain California's limited water supply, we will need to diversity the drinking water supply. While many experts insist that potable reuse is a safe and sustainable method of diversifying the drinking water portfolio, research shows that negative public perception is the greatest obstacle to implementing potable reuse (Millan et al., 2015; NWRI, 2016; Sedlak, 2014; Tchobanoglous et al., 2015). For this thesis, a survey was conducted in order to evaluate the opinions and concerns of college students, a population that has been underrepresented in previous research. The purpose of this research was to explore how attitudes and opinions towards potable reuse vary among college students depending on their academic major, as well as their understanding of and concern about tap water networks and drought conditions. The results suggest that SF State students are more likely to support potable reuse and to drink recycled water if they already drink tap water at home, are concerned about the drought in California, and believe that droughts will continue to increase in severity.

The results of this study have the potential to inform policy makers and public outreach in the water sector. Younger, drought-concerned and water-conscious individuals in the San Francisco Bay Area may be more likely to support potable reuse. The majority of the students surveyed relied on their local tap water and are concerned about the future drinking water supply. This would suggest that local water utilities should focus on stressing the importance of creating a sustainable, resilient and droughttolerant public water supply. This might help further shift attitudes towards more acceptance and approval of potable reuse projects.

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Appendix A

Water Reuse Survey

As part of my Master's thesis in Geography at San Francisco State University, I am conducting a survey to learn more about student's opinions and attitudes towards recycled water for drinking purposes. The information from the survey will be used for scholarly purposes only. Your opinion and participation is greatly appreciated!

Your participation in this survey is voluntary. If you decide not to participate in this study or if you withdraw from participating at any time, you will not be penalized. All information will be kept strictly confidential.

Please read each question carefully and answer honestly. The survey only takes approximately 5 minutes to complete!

THANK YOU!

Clicking the "agree" button indicates:
*You have read the above information
*You voluntarily agree to participate
*You are at least 18 years old of age
*You are a current student at San Francisco State University
If you do not wish to participate in the survey, please decline by clicking the "disagree" button

- ❍ Agree
- ❍ Disagree

If Disagree Is Selected, Then Skip To End of Survey

Where do you currently live?

- ❍ Alameda County
- ❍ Contra Costa County
- ❍ Marin County
- ❍ Napa County
- ❍ San Francisco County
- ❍ San Mateo County
- ❍ Santa Clara County
- ❍ Solano County
- ❍ Sonoma County
- ❍ Other ____________________

What is your zip code?

Do you drink tap water at home?
- ❍ Yes
- ❍ No

Display this question:
If do you drink tap at home? No, is selected
What is the main reason you do not drink tap water at home?
- ❍ It doesn't taste good/smell right
- ❍ I don't trust that its safe to drink
- ❍ It looks dirty
- ❍ I prefer bottled water for drinking
- ❍ Other ____________________

Do you know where the main source of your tap water comes from?
- ❍ Yes
- ❍ No

Display this question:
If Do you know where the main source of your tap water comes from? Yes, is selected
Is your tap water supply from a private groundwater well?
- ❍ Yes
- ❍ No

Display this question:
If Where do you currently live? Alameda County is selected
And Do you know where the main source of your tap water come from? Yes is selected
And is your tap water supply form a primate groundwater well? No is selected
Select the water source that best fits your main tap water supply in Alameda County
- ❍ State Water Project
- ❍ Mokelumne River via Padre Reservoir
- ❍ Hetch Hetchy Reservoir
- ❍ Lake Pillsbury
- ❍ I do not know
- ❍ Other ____________________

Display this question:
If Where do you currently live? Contra Costa County is selected
And Do you know where the main source of your tap water come from? Yes is selected
And is your tap water supply form a primate groundwater well? No is selected
Select the water source that best fits your main tap water supply in Contra Costa County
- ❍ The Central Valley Project via Contra Costa Canal
- ❍ State Water Project

- Hetch Hetchy Reservoir
- Lake Pillsbury
- I do not know
- Other ____________________

Display this question:
If Where do you currently live? Marin County is selected
And Do you know where the main source of your tap water come from? Yes is selected
And is your tap water supply form a primate groundwater well? No is selected
Select the water source that best fits your main tap water supply in Marin County

- Lagunitas, Pheonix, Alpine, Bon Tempe, Kent, Nicasio and Soulajule Reservoir
- Central Valley Project
- State Water Project
- Hetch Hetchy Reservoir
- I do not know
- Other ____________________

Display this question:
If Where do you currently live? Napa County is selected
And Do you know where the main source of your tap water come from? Yes is selected
And is your tap water supply form a primate groundwater well? No is selected
Select the water source that best fits your main tap water supply in Napa County

- Milked Reservoir and Lake Hennessy
- Hetch Hechty Reservoir
- Lake Pillsbury
- Central Valley Project
- I do not know
- Other ____________________

Display this question:
If Where do you currently live? San Francisco City/County is selected
And Do you know where the main source of your tap water come from? Yes is selected
And is your tap water supply form a primate groundwater well? No is selected
Select the water source that best fits your main tap water supply in San Francisco City/County

- Hetch Hetchy Reservoir
- Lake Pillsbury
- State Water Project
- Central Valley Project
- I do not know
- Other ____________________

Display this question:
If Where do you currently live? San Mateo County is selected
And Do you know where the main source of your tap water come from? Yes is selected
And is your tap water supply form a primate groundwater well? No is selected
Select the water source that best fits your main tap water supply in San Mateo County

- ❍ Hetch Hetchy Reservoir
- ❍ Lake Pillsbury
- ❍ State Water Project
- ❍ Central Valley Project
- ❍ I do not know
- ❍ Other ____________________

Display this question:
If Where do you currently live? Santa Clara County is selected
And Do you know where the main source of your tap water come from? Yes is selected
And is your tap water supply form a primate groundwater well? No is selected
Select the water source that best fits your main tap water supply in Santa Clara County

- ❍ State Water Project and Central Valley Project
- ❍ Lake Berryessa
- ❍ Lake Pillsbury
- ❍ Russian River
- ❍ I do not know
- ❍ Other ____________________

Display this question:
If Where do you currently live? Solano County is selected
And Do you know where the main source of your tap water come from? Yes is selected
And is your tap water supply form a primate groundwater well? No is selected
Select the water source that best fits your main tap water supply in Solano County

- ❍ Lake Berryessa via Putah South Canal
- ❍ Sacramento River
- ❍ Hetch Hetchy Reservoir
- ❍ Central Valley Project
- ❍ I do not know
- ❍ Other ____________________

Display this question:
If Where do you currently live? Sonoma County is selected
And Do you know where the main source of your tap water come from? Yes is selected
And is your tap water supply form a primate groundwater well? No is selected
Select the water source that best fits your main tap water supply in Sonoma County

- ❍ Lake Pillsbury and Lake Mendocino

- ❍ Hetch Hetchy Reservoir
- ❍ State Water Project
- ❍ Central Valley Project
- ❍ I do not know
- ❍ Other ____________________

Do you know what kind of treatment(s) your tap water goes through to make it drinkable?

- ❍ Yes
- ❍ No
- ❍ Unsure

Display this question:
If Do you know any disinfection methods your tap water goes through to make it drinkable? Yes is selected
Please name a method(s) of treatement that your drinking water goes through to make it drinkable

Do you know what happens to your wastewater (shower, toilet, sinks, etc) after it goes down the drain?

- ❍ Yes
- ❍ No
- ❍ Unsure

Display this question:
If Do you know what happens to your wastewater after it goes down the drain? Yes is selected
Select the option that best describes what happens to your wastewater after it goes down the drain

- ❍ Flows through the sewer and directly out to the Bay or Ocean
- ❍ Flow to the closest wastewater treatment plant where it is stored
- ❍ Flows to the closest wastewater treatment plant before being discharged to the SF Bay, Pacific Ocean, or a local river
- ❍ Flows to the closest wastewater treatment plant before being completely reused

Other ____________________

Please rate your level of concern for your current tap water for each of item below

	Very Concerned	Concerned	Neutral	Somewhat Concerned	Not at all Concenered
Quantity of your drinking water supply	❍	❍	❍	❍	❍

Quality of your drinking water supply	❍	❍	❍	❍	❍
Conditions of your household pipes	❍	❍	❍	❍	❍
The state of the water infrastructure (dams, pipes, pumps, etc)	❍	❍	❍	❍	❍
Treatment standards for drinking water	❍	❍	❍	❍	❍

How concerned are you about the current drought in California?
❍ Very concerned
❍ Concerned
❍ Neutral
❍ Somewhat concerned
❍ Not at all concerned

Do you feel El Niño has, or will, relieve us from this current drought in California?
❍ Yes
❍ No
❍ Not sure

Do you believe droughts in California will increase in severity in the future?
❍ Yes
❍ No
❍ Not sure

Potable Reuse refers to recycled wastewater that is treated for drinking purposes. The process starts with using wastewater and treating it to be purified sufficiently enough to meet or exceed federal and state drinking water standards and is safe for human consumption. (EPA Guidelines to Water Reuse 2012, WaterReuse Glossary 2016) Before taking this survey, were you familiar with the concept of potable reuse?
❍ Yes
❍ Somewhat
❍ No

Advanced treated water: The treatment of wastewater for potable proposes goes through several methods of treatment including, micro filtration, activated carbon, reverse osmosis, advanced oxidation processes, soil aquifer treatment, etc.   Before taking this survey, were you familiar with the "advanced" treatment process of potable reuse?

- Yes
- Somewhat
- No

Are you familiar or aware of any current potable reuse projects in California or the US?

- Yes
- No

Display this question:
If Are you familiar or aware with any current potable reuse project in the US? Yes is selected
Please name the potable reuse project(s) you are aware or familiar with

How likely are you to support recycled water for drinking purposes (potable reuse) in your municipality?

- Very likely
- Likely
- Neutral
- Unlikely
- Very unlikely

How likely are you to drink recycled wastewater treated to drinking (potable) standards?

- Very likely
- Likely
- Neutral
- Unlikely
- Very unlikely

Display this question:
If How likely are you to drink recycled wastewater treated to drinking (potable) standards? Very unlikely is selected
Or How likely are you to drink recycled wastewater after treatment to drinking (potable) standards? Unlikely is selected

Please select the main reason for NOT being likely to support or drink recycled water treated to potable standards

- ❍ Unsafe/unclean/health concerns
- ❍ I don't know enough about it
- ❍ I don't trust the municipality to properly manage the treatment and distribution of it
- ❍ The water will taste and/or smell bad
- ❍ It's too energy intensive
- ❍ There are other water resources that can be used before reusing the wastewater
- ❍ Other ____________________

Display this question:
If How likely are you to support recycled water for drinking purposes (potable reuse) in your municipality. Very likely is selected
Or How likely are you to support recycled water for drinking purposes (potable reuse) in your municipality. Likely is selected

Please select the main reason for being likely to drink or support recycled wastewater treated to potable standards

- ❍ The water is safe and clean to drink
- ❍ Recycled water is already being used in other places
- ❍ The water municipality knows what it's doing, I trust them
- ❍ The quality of potable reuse is higher than most tap and bottled water
- ❍ It's less energy intensive than other water supply options, like desalination or new dams
- ❍ Water shortage and drought
- ❍ Other ____________________

What is your gender identity?

- ❍ Male
- ❍ Female
- ❍ Other ____________________

How old are you?

Where are you from (where did you grow up for the most part)?
- ❍ San Francisco Bay Area
- ❍ California, but outside of the Bay Area
- ❍ Another State, outside of California
- ❍ Outside of the United States

What is your grade level?
- ❍ Undergraduate
- ❍ Graduate
- ❍ Other ____________________

What academic department or major are you in at San Francisco State University?
- ❍ Biology
- ❍ Engineering
- ❍ Environmental Studies
- ❍ Urban Studies and Planning
- ❍ Health Education
- ❍ Geography & Environment
- ❍ Department of Earth & Climate Sciences
- ❍ Other ____________________

Optional question What ethnic group do you identify with?
- ❍ Black or African American
- ❍ American Indian, Alaskan Native
- ❍ Asian (including Filipino)
- ❍ Chicano, Mexican American
- ❍ Latino
- ❍ Pacific Islander
- ❍ Two or more races
- ❍ White Non-Latino
- ❍ Other ____________________

Where did you find this survey?
- ❍ An email from my academic department Office Manager
- ❍ An email from one of my professors in my department
- ❍ An email from a friend
- ❍ A Facebook post
- ❍ An email and a Facebook post
- ❍ A flyer at school
- ❍ Others ____________________

Display this question:
If Where did you find this survey? A Facebook post is selected
And Where did you find this survey? An email and a Facebook post is selected
On what Facebook page or group did you hear about this survey?