The Water Use Efficiency Rule and Over Compliance: An Analysis of Water Conservation in the State of Washington

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This is to certify that I have examined this copy of the Capstone manuscript by

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Table of Contents

Chapter 1: Background

The Water Municipal Law and the Water Use Efficiency Rule

Water conservation has always been a very important issue, especially in the last decade or so. With droughts becoming more of a "norm" rather than an infrequent event, growing populations, and many other circumstances that threaten water supply, cities and states must begin to think about ensuring the security of their future water supplies. In Washington State, in 2003, the Legislature passed Engrossed Second Substitute House Bill 1338, also known as the Municipal Water Law (MWL), that required all municipal water suppliers to use water more efficiently to ensure that future water demands of the state were met in exchange for allowing these suppliers to keep their unused water rights. Because the law required water efficiency, the Water Use Efficiency (WUE) Rule was incorporated into the Municipal Water Law to meet this requirement.

The MWL was challenged by the King County Superior Court in 2008, Lummi Indian Nation v. State, regarding three sections of the law, which included the sections on water rights, and the definitions of "municipal water supplier" and "municipal water supply purposes" (Ecology 2011). The Washington State Supreme Court upheld the constitutionality of the law and ruled in favor of the State of Washington on October 28, 2010 (Office of Drinking Water 2011a).

In 2007, the Water Use Efficiency Rule became effective, requiring municipal water suppliers (MWS) to implement demand- and supply-side water conservation goals while also reducing water system leakage to less than 10%. The rule also mandates that each MSW host a public forum open to all consumers in their service area to comment on and establish at least one of water savings goal. Other requirements of the WUE include an evaluation of existing and

proposed measures, implementation of the agreed-upon water saving measures to achieve the goals, the development of a water efficiency planning program to support the goals, installation of meters to all connections by 2017, achievement of no more than 10% water loss per year, and submittal of an annual report detailing the progress to achieving those goals to the Department of Health (Office of Drinking Water 2011b).

Research Objectives

The objective of this study was to identify correlative relationships between voluntary over compliance to the WUE Rule and factors that may influence over compliance. The analysis was focused on how the characteristics of the rules and water supply along with attributes of the community can affect the action arena, the decisions, and the outcomes of over compliance to the WUE Rule. The factors examined in the paper will include demographics (population, median income, and educational attainment), regional programs or partnerships with other municipalities, the size of the system, and geographical location. A statistical analysis was performed to see if any of these variables were statistically significant in correlation with over compliance. Following a review of the relevant literature, I formed several hypotheses regarding the variables that could influence over compliance to the WUE Rule.

Requirements of the Water Use Efficiency Rule

In order for the municipal water suppliers to comply with the water use efficiency program, they must address these aspects in their annual report (WAC 246-290-810):

- A description of the current water use efficiency program (if they have one);

- A description of their chosen water use efficiency goals and documentation that the goals were established;

- An evaluation of cost-effectiveness of the water use efficiency measures;

- A description of all water use efficiency measures to be implemented within the next six years, including a schedule and budget;

- A description of how consumers will be educated on water use efficiency practices;

- An estimate of the projected water savings from their water use efficiency measures;

- A description of how their program will be evaluated for effectiveness;

- An evaluation of the water distribution system leakage by including distribution system leakage totals for the past six years, which could include a copy of the water loss control action plan, and if all or portions of transmission lines are excluded when determining distribution system leakage;

- Provide an estimate the amount of leakage from the excluded portion of the transmission mains and describe how it is maintained to minimize leakage;

- If the system has 1,000 or more total service connections, they are also required to give an estimation of the amount of water saved through implementation of the water use efficiency program over the last six years.

To determine cost effectiveness of their water use efficiency plan, the supplier needs to evaluate or implement, at a minimum, the number of water use efficiency measures based on the system's total number of connections (see Table 1). If applicable, the municipality must also evaluate or implement water use efficiency measures from the following categories: indoor residential, outdoor, and industrial, commercial, institutional (WAC 246-290-810). However, for systems serving less than 1,000 total connections, they must describe the evaluation process used

to select water use efficiency measures, and evaluate their measures quantitatively to determine

if they are cost-effective from the system's perspective including the marginal costs of producing

water (WAC 246-290-810). Along with this evaluation, they must also address whether the

measures are cost-effective, if the costs are shared with other entities, and quantitatively or

qualitatively evaluate water use efficiency measures (WAC 246-290-810). Although the annual

report documentation required for the Water Use Efficiency Rule is not as extensive as outlined

above, this information must be incorporated into a required water conservation plan. A

municipal water supplier is required to update their water conservation plan every six years, so

this information is important to collect and evaluate for the purposes of updating a new water

conservation plan as well as reporting annually to the Department of Health about their goal

progress.

Enforcement of the Rule

Currently, the Office of Drinking Water initially reviews the submitted water efficiency

plan and planners may withhold approval until the municipality has demonstrated compliance

with the WUE regulations (Office of Drinking Water 2011c). Some violators may be targeted for

more formal enforcement if the municipality fails to demonstrate compliance the WUE

requirements, which may affect the status of their water operating permit (Office of Drinking

Water 2011c). The Office of Drinking Water collects and reviews the annual reports, and creates

a list based on those who did not comply with the reporting requirement of the WUE Rule. They

are labeled "non-compliant water systems" until a report is submitted. The municipalities are

individually contacted, told to submit their reports as soon as possible, and are publicly listed on

the Department of Health Office of Drinking Water's website

(http://www.doh.wa.gov/ehp/dw/programs/wue.htm).

Description of the Decision Maker

According to the WAC 246-290-020 (2003), a public water supplier or municipality is defined as any public system that provides water for human consumption through pipes or other constructed conveyances. Exceptions include systems serving only one single-family residence and a system with four or fewer connections, all of which serve residences on the same farm. This term includes the collection, treatment, storage, and/or distribution facilities under control of the purveyor and used primarily in connection with the system, and collection or pretreatment storage facilities not under control of the purveyor, but primarily used in connection with the system (WAC 246-290-020 2003). Municipal water suppliers are most commonly known as a public water utilities or water districts, but also include mobile home parks and water associations.

There are two types of public water systems in Washington State: "Group A" and "Group B." The water municipalities that are required to submit reports, in compliance with the Water Use Efficiency Rule, are defined as "Group A" water systems, defined as regularly serving 15 or more residential service connections, or 25 or more people per day for 60 or more days per year (WAC 246-290-020). "Group B" water systems are defined as serving fewer than 15 residential service connections; those designated as "Group B" water systems are not required to submit annual Water Use Efficiency rule reports.

<u>Definitions</u>

Service connections

Service connections are the pipelines that run from a water system to a commercial building, schools, housing or streets, and are the individual parts of the distribution system that comes from the municipal water supplier (WSDOH 2009). Service connections are also the sites for much of the distribution leakage and water loss that a municipal water supplier must track and address. Leaky pipes are also a source of reduced water quality and bacteria contaminants (DOHODW 2008). One of the requirements of the Water Use Efficiency Rule is to have 10 percent or less leakage distribution and report the percent leakage in the annual report.

Water Rights

In Washington State, a water right is defined as "a right to a beneficial use of a reasonable quantity of public water for beneficial purpose during a certain period of time occurring at a certain place" (OAG 2000). This definition is very vague, but a typical definition of a water right in the Western U.S. One who holds a water right must be able to demonstrate the full quantity of water claimed has been continuously used for a "beneficial purpose." Municipal water supply is seen as a beneficial use, even if the water right is left unused because it can provide some secure future water supply (OAG 2000). The Municipal Water Law allows municipalities to keep unused water rights, even though by definition, this is not a beneficial use.

Measures

A measure identifies specific tools, policies, and practices that achieve demand-side efficient water use. They are also known as an incentive or program that promote water conservation. Example measures range from behavioral changes, education, and efficient upgrades, which include: hardware devices like low-flow showerheads and aerators, campaigns for water conservation, rebates on water-saving toilets and clothes washers, and educational school programs (teaching materials, classroom presentations, field trips, etc.). Supply-side measures are required as well, such as replacing meters on water sources and customer connections, but these measures are not counted towards the required number of measures to be implemented, and therefore, were not included in this over compliance analysis.

Over Compliance

There are several requirements to be in compliance with the WUE. Each municipal water supplier is required to adopt and implement a specific number of measures dependent on the number of total connections. Each municipality must adopt a supply-side and demand-side goal. One of the demand-side measures must have an educational component. The minimum requirements are written broadly, allowing each municipality the flexibility to determine goals and implement measures that are most financially and socially feasible. Table 1 shows how many measures are required for implementation dependent on the number of total connections. Municipalities with 1,000 or more connections are also required to evaluate reclaimed water options as a measure. A municipality is in over compliance if it chooses to implement more measures than the minimum requirement. This study is focused on one aspect: the implementation of demand-side measures and programs by each municipality.

Table 1 - Required Measures To Be Implemented According to Number of Connections

Number of Service Connections	Less than 500	500-999	1,000-2,499	2,500-9,999	10,000-49,999	50,000 or more
WUE Measures	1	4	5	6	9	12

(Office of Drinking Water 2011c)

Chapter 2: Literature Review

The literature reviewed for this study focused on water conservation and future water supply threats and strategies. Relevant topics in the literature reviewed included common pool resources, environmental regulations, voluntary over compliance by firms, environmental values related to demographic characteristics, and collaborative environmental management. This literature helped me to form my hypotheses as well as determine some of my independent variables, which include socioeconomic factors, location, size of the system, and partnerships.

Environmental Justification for Water Conservation

There are significant threats to the Washington State's water supply, including climate change, growing populations, and periodic droughts. As those threats become more apparent, the need to develop water supply solutions that will work in the short- and long-term is becoming more urgent. Models indicate that climate change is going to make weather patterns extremely unpredictable. Most 21st century models for the Puget Sound show a zero to ten percent increase in winter precipitation, a reduced winter snowpack due to increased temperatures, earlier snowmelt, higher incidences of flooding, a reduced stream flow in summer, and many other discouraging forecasts that will negatively affect water supply and quality (Snover et al. 2005). These changes will not only affect humans, but also greatly affect the ecosystems that rely on a constant source of water. Although water conservation cannot solve climate change, it can mitigate the impacts might experience from a drought or a continuously growing population.

With an ever growing worldwide and national population, water resources are being stretched to their limit. Cities and states are facing the same threats to water supply, and policy makers must realize that as their communities grow water supply will also need to grow unless

demand efficiencies are realized. In Washington State, water uses varies from municipal water use to hydropower to agricultural use to recreation. Different parts of the state experience different kinds of climates as well. Precipitation changes will affect water resources in very different ways: water shortages are projected to occur more frequently in the Yakima Basin which will affect the average production of apples and cherries, lower summer stream-flow and higher stream temperatures will reduce the quality and extent of freshwater salmon habitat in the Columbia River basin, hydropower production is likely to decline by 9 to 11 percent during the summer, urban water supply systems in Puget Sound will collect less water in their reservoirs in the spring and early summer, and drought stress is likely to reduce forest productivity in eastern Washington (Adelsman and Ekrem 2012). Along with droughts, increased temperatures and increased winter precipitation will lead to frequent flooding: in western Washington, flood risk is generally highest in late fall and winter when precipitation is greatest while in eastern Washington, flood risk is generally highest during the spring snowmelt (Adelsman and Ekrem 2012). These climate change events trigger a need to address climate change and future water supplies.

Roessler (2008) describes how major cities in the arid west have had to examine ways to meet those demands, specifically looking at supply- and demand-side solutions. For cities that prioritize growth, they seek to find supply-side solutions to increase their supply such as investments in water storage, water transfers, specifically building pipelines to bring water to their area, or saltwater desalination (Roessler 2008). However, these are not typically the most cost-effective solutions as these projects range in the millions of dollars.

One of the most cost-effective solutions is a focus on demand-side solutions like water conservation and efficiency. Not only is it less expensive, but it is also better for the

environment. Reducing the demand per person in water supply can serve more people with the same amount of water, eliminating the need to find or divert new water supplies (Roessler 2008). It is important to note that "[f]or every dollar invested in water conservation efforts, fourteen dollars are spent on developing new supplies, and close to 90 percent of water conservation spending has been on turf removal" (Roessler 2008). Even though utilities are debating whether or not to invest in capital projects for supply storage, it is now required to allocate funding and devote efforts towards water conservation. Not only is an investment in demand-side solutions cost-effective, they have been proven to reduce water demand without having to build new pipelines to meet a growing population.

Institutional Rational Choice Framework and Common Pool Resources

The initiation, characteristics, and success of water conservation efforts is presumably related to resource user values. To test this supposition, the motivations for water conservation and its impact on water use behavior can be analyzed within the Institutional Rational Choice framework outlined by Elinor Ostrom (1999). The model starts with specifically looking at the characteristics of the resource, the community, and the institutional arrangement, to determine "the action arena," which affects decision-making and outcomes (Ostrom 1999).

The resource in this case is water and its distribution and supply to the public. Although some consumers do not consciously think about where the water is coming from, besides out of the tap, municipal water suppliers must constantly think about the supply and meeting the consumer demand.

The community makes up those who are served by the municipality within the service area, the staff at the municipal water supplier, any political board or City Council that is in

charge of municipality's policies, and those that voluntarily enter a partnership. The actors that are affected most by the policies are the consumers because not only are they are the revenue source for the municipality, but they also have to comply with new water conservation measures that encourage them to decrease their overall demand. The staff of the municipality is also affected because they need to know and understand all the policies that are proposed and adopted, and must teach their customers about these policies. These policies add more responsibility to staff members to carry them out. The policy makers have the important decisions of goal setting, attainment, and implementation. Everyone is feeling the pressure with economic budget constraints and having to reduce spending; environmental issues are hard to prioritize when other important programs are losing funding. In this case, the WUE Rule has to be implemented, so some money has to be prioritized towards a water efficiency program.

The institutional arrangements include the Water Municipal Law, the Water Use Efficiency Rule, and the water municipality policy makers that adopt and implement water conservation measures and goals. The WUE Rule requires water municipalities to submit descriptions of their water supply, identify water conservation measures that have already been implemented within the service area, estimate the amount of leakage in the distribution system, propose new water conservation measures, and discuss the progress made on their water conservation goals. The WUE Rule is written in a way that allows flexibility for implementation instead of a prescriptive set of policies allowing each individual municipality the most economically and politically feasible solutions towards reaching a self-imposed goal. Because of this flexibility, it should allow the municipality to successfully reach and potentially exceed their goals.

The required output is a water conservation plan which meets the requirements determined by the water use efficiency program (WAC 246-290). As these are more clearly defined as a requirement of implementation and integration of a water efficiency plan, this affects the decision making process at the water municipality level in hopes of the outcome of decreased water consumption. The municipality and its staff must walk a fine line between stringency and flexibility to in order to make their water conservation goals and find a way to get all of the community on board with the same decisions, while reporting all this information to the Department of Health.

In this study, I focused on how the characteristics of the institutions and the resource along with attributes of the community can affect the action arena, the decisions, and the outcomes towards compliance to the WUE Rule.

Environmental Over Compliance and Firms

Even though this literature is focused on private sector instead of public sector organizations, Denicolo (2008) explains that there are two main reasons why firms over comply with environmental regulations: a response to concerned consumers or to preempt more stringent regulations in the future. If government regulators adopt stricter regulations, then the firms that have already adopted more efficient practices will have an advantage over their rivals (Denicolo 2008). In a public utility, however, the motivation behind more efficient practices would not be to out compete another competitor, because there is no one else to be in competition with, but to potentially preempt stricter regulations. Other potential reasons why a municipal water supplier would over comply is to expand their supply reservoir to meet a projected demand, to seek environmental benefits like conserving stream flows for fish species, or providing a buffer to

mitigate the impacts of drought. Furthermore, the WUE Rule encourages the public to attend meetings and comment on draft plans to express their opinions about the proposed goals and measures before adoption. Consequently, MWS plans to comply with the WUE Rule can be motivated by a combination of both consumer response and preemption of stricter regulations.

Shimshack and Ward (2008) reviewed an extensive body of literature in their attempt to explain over compliance to environmental regulations. This literature showed that consumer preferences for environmental quality can generate over compliance as a market outcome. But the aspect that Shimshack and Ward (2008) focus on was how variation in the degree of over compliance can be attributable to the variation in enforcement stringency. Thus Shimshack and Ward (2008) found that the variation of over compliance is driven by traditional economic incentives rather than altruistic intentions, and enforcement can induce changes to the degree of over compliance. They also found that if there was a small investment in traditional adversarial enforcement, environmental quality might also increase. However, the findings of Shimshack and Ward (2008) do not appear to apply to the municipal water suppliers of Washington State. The WUE Rule lacks strict enforcement after plans are approved and submitted, besides a "name-and-shame" public listing, yet municipalities still voluntarily choose to over comply

Demographics and Water Conservation Attitudes and Behaviors

Countless studies have been done to understand the relationship between demographics of people and their environmental attitudes. This includes studies relating demographics to water conservation attitudes and behaviors. There have been many correlative studies between environmental conservation attitudes and demographic characteristics such as income, education, political party, ethnicity and home ownership (De Oliver 1999). De Oliver (1999) cites several

studies indicating a positive relationship between income and education with conservation attitudes. He also states that even though support for a specific political party does indicate a general preference towards environmentalism, it is not wholly indicative of environmental preference (De Oliver 1999).

De Oliver's (1999) test area was San Antonio, Texas. The most interesting results De Oliver (1999) found was during the voluntary stage of water conservation. He found that communities with the highest water savings were relatively wealthier, had higher education achievement, were politically conservative, and of Anglo descent. However, when mandatory water conservation regulations were enacted, the correlations to demographic characteristics were negligible. There was no specific pattern of characteristics of water savers, except for those who lived in detached housing who would save more water (De Oliver 1999). This research showed that even though there can be specific demographic characteristics that favor water conservation, it is also dependent on the area and manner in which the water conservation measures are implemented.

Understanding the customer base in a water service area is important to determine what kinds of measures and programs will most likely be effective or feasible in water conservation. Gilg and Barr (2006) determined that enhanced conservation activities are normally associated with higher income groups, more politically liberal customers, smaller family sizes, and smaller property owners. However, there are many other factors that influence conservation behaviors such as price and economic incentives, environmental threat, social desirability, perceived water rights, and intrinsic motivations (Gilg and Barr 2006). The study found that those who were *most* committed to water conservation were older, likely owned their home, voted liberally, and were members of a community organization. Although this study was focused on the behavior of

a community in the United Kingdom, I infer the same likelihood of water conservation behaviors seen in most developed countries.

Efficiency and Productivity

Efficiency and productivity are important for any kind of business to thrive and it is no different in the utility sectors. The goals behind comprehensive conservation programs like WUE Rule can be varied between states, but in most cases, these programs are trying to achieve long-term reductions in water demand of a service area, ensure public health and water quality, promote good stewardship of our resources, and ensure efficiency in operations and management of water systems (Office of Drinking Water 2011). Not only are conservation programs beneficial for the service area to ensure long-term water supply, it is also an environmental benefit. The ways to achieve these goals are the implementation of measures to reach reduced water demand goals. Vickers (2001) writes that conservation measures and incentives are methods for increasing water efficiency, which can be categorized into three types: educational, financial, and regulatory. Depending on the municipality, they can choose to implement any of these forms to ensure achievement of their self-imposed goals.

Abbott and Cohen (2009) specifically studied several different factors of efficiency and productivity in the water supply industry, which included economies of scale, economies of scope, public versus private ownership, and regulatory effects, which included health, environmental, planning, and economic. Small and medium sized municipalities show characteristics of vertically integrated operations and tended to have geographical monopolies. Larger metropolitan systems tended to have a reliance on multiple sources of water, and several vertically integrated entities with separate distribution networks (Abbott and Cohen 2009).

However, all systems are managing a scarce natural resource, and because of the scarcity, monopoly characteristics, externalities, and welfare concerns, government can choose to enforce regulation to reduce these costs. Abbot and Cohen (2009) found that regulatory affects, dependent on the type implemented, like a price cap, were important influences on the level of productivity and efficiency of water suppliers in the U.S. Now that water conservation is a mandatory law, municipalities are required to look at how they currently manage water supply and implement measures that will ensure future water supply while also taking externalities and welfare concerns into consideration.

Collaborative Environmental Management

When managing natural resources or common pool resources, the past history has been to use "command-and-control" policies to help solve problems, but policy makers are starting to realize that a collaborative component to resource management can help to create policies that everyone can take part in while also solving environmental problems. The WUE Rule encourages municipalities to develop or join partnerships to share resources and information, lower costs, and increase public acceptance and awareness. Water systems with similar characteristics may have already successful implemented WUE measures and could share the program information with others. When information and resources are shared, transaction costs are lowered making it a win-win situation for all parties involved in a partnership.

Even though, in the case of WUE Rule, the requirement of public participation is minimal, there is no rule against encouraging a higher level of collaboration at each individual municipality. They do so by engaging the public during the public forum or by voluntarily entering into a partnership with another municipality or regional group.

Sabetier et al. (2005) asserted that collective action problems in watersheds emerge from the political contracting processes. This process allows various stakeholders to agree on a set of institutional rules on how to govern their resources and how to cooperate on implementation. The public forum is meant to assist this process by encouraging the public to comment on the proposed WUE goal and measures. However, there are transaction costs associated with this collaborative process in the forms of cost-benefit analysis of alternatives, negotiating those alternatives into a final agreement, and monitoring compliance to the agreement (Sabetier et al. 2005). But that is why there is a requirement of annually reporting goal progress as a part of compliance to ensure that the agreement is being upheld.

Chapter 3: Methodology

Variable Conceptualization and Operationalization

This chapter discusses my methodology, which includes: the research question, the variables, my model, my hypotheses about over compliance, data collection methods and sources, and sampling method.

Research Question: What are the factors that influence voluntary over compliance to the requirements of the Water Use Efficiency Rule by water municipalities in the state of Washington?

I posed this question in order to understand if there is a causal relationship between over compliance and factors including demographic characteristics by county (median income, education attainment: Bachelor's degree or higher, and population size), partnership with another municipality or regional program, the size of the system (the number of connections), and geographical location (county location: East or West). Figure 1 provides a conceptual model of these factors hypothesized to be the most important influences towards over compliance. My hypotheses come from my literature review, which heavily rely on the research about demographics and the institutional rational choice model, as well as location information about Washington State and its water uses.

The unit of analysis is a single municipality, also known as a water district, city, or public utility. There are two different types of municipalities defined as Group A or Group B. Group A is defined as serving 15 or more residential homes and Group B serves fewer than 15. There are

also public and private municipalities. My sampling only includes those that meet the definition

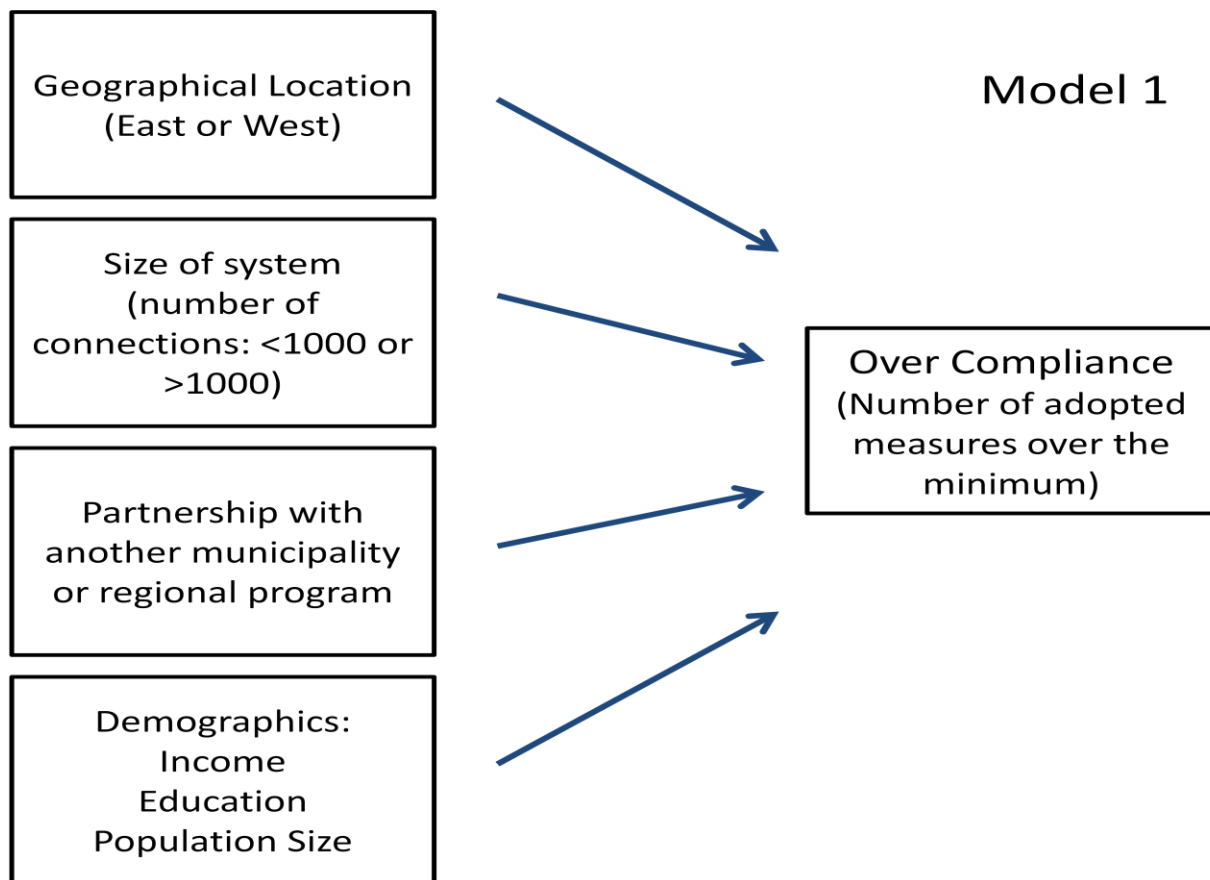of a Group A municipality and are publicly owned.

Figure 1. A conceptual model of independent variables hypothesized to influence over

compliance to the WUE Rule by municipalities.

I hypothesize that:

1. *There will be a relationship between the number of municipalities that over comply and*

   where they are located. There will likely be over compliance in municipalities located in

   western Washington and not in eastern Washington.

   I hypothesized this because water uses vary a great deal in eastern versus western

   Washington. Most of the crop production is in the eastern part of the state, which also

experiences a dryer climate compared to western Washington. Because a majority of eastern Washington is agriculture land, more stringent water efficiency programs might be resisted.

2. A municipality will over comply when the service area is larger (higher population or number of connections).

This was hypothesized because a larger system would likely have a larger budget to spend on the WUE Rule compliance; the more revenue collected by the municipality that serves a higher population in the service area, the more resources could be spent on their water efficiency program and where more potential measures could be implemented.

3. A municipality will over comply when they are partnered with a regional program.

This was hypothesized because collaborative efforts could potentially lower individual transaction costs. Because those involved a partnership are collaborating on a water efficiency goal to be adopted, they will make the goal attainable by all parties as well as creating an environment to share resources and information.

4. A municipality will over comply if the median income in the service area is higher than the state average.

5. A municipality will over comply if the median education attainment in the service area is higher than the state average.

The last two hypotheses were based on the article by De Oliver (1999) demonstrating how consumers with higher socioeconomic status and education attainment were more likely to have higher environmental values.

Data Sources and Collection Methods

The data sources used for my research question included the 2010 WUE annual reports submitted to the Department of Health (Office of Drinking Water), which are based on 2009 baseline data, municipal water plans, and the U.S. Census 2010 data. The 2010 WUE annual reports included calculations of distribution system leakage and narrative information such as metering installment progress, the WUE supply- and demand-side goals, goal setting, progress in reaching the goals, and any other additional information provided by the municipality. These reports are used by the DOH to evaluate municipal progress of the self-imposed WUE goals.

In order to gather more detailed information about each municipality's WUE Rule compliance, I worked in collaboration with the Partnership for Water Conservation, a local non-profit organization engaged in state-wide water conservation efforts. The data from their individual water efficiency plans specify the compliance measures employed, identify any partnership with other municipalities or region that set water conservation goals, and the size of system. In determining geographical location, I used the Cascade Mountain Range, which divides Washington State from north to south, to code the individual municipalities in either Eastern or Western Washington. From the U.S. Census 2010 data, I gathered information about the population size, median income, and educational attainment percentage (Bachelor's degree) of each county in Washington State.

Sampling

There was a total of 482 reports that were submitted to the Department of Health as baseline data for 2009. In order to created a representative sample, I used a method called stratified sampling, which looks at a number of elements from the population of municipalities

that submitted reports; those elements included the location of the municipality by county, and the number of connections in the system (under or over 1,000 connections) (Babie 2001).

Each municipality is required to report on how many connections are in their system so I chose small, medium, and large municipalities from each county to make sure each type of system was represented. Small systems were defined as fewer than 100 connections, medium systems between 101 and 10,000, and large systems above 10,001 connections. Geographically, I also wanted each county to be represented in the sample. The counties in Washington varied in size, and the number of municipalities that submitted reports within those boundaries also varied. Smaller counties with fewer municipalities were all contacted for detailed information, while larger counties with more municipalities to choose from were sampled by size. For example, if there were fewer than five municipalities located within a county that submitted a report, they were all contacted and asked to provide information about their Water Use Efficiency plan. If there were more than five within a county, the size of the system (number of connections) was taken into consideration to create a more representative sampling.

Analytical Method

Statistical analysis is necessary in order to understand this relationship and to see if there is any statistically significant correlation between my independent and dependent variables. I performed a distributional analysis on the sample for a breakdown and to model the frequency of over compliance, and then an OLS regression to determine which variables showed any statistical significance. For this research question, my dependent variable is whether or not a water municipality has over complied; this means the number of measures and programs implemented that exceeded the minimum requirement for the size of the system. I extracted the data from the WUE reports from the Department of Health, counted the number of measures that

each municipality implemented or evaluated to meet demand-side efficiency goals, and determined how many municipalities that over complied, meaning implementation of one or more above the required minimum. I did not take into account other characteristics of the municipality to see if over compliance was also linked to a specific set of elements. Because my dependent variable is a count variable, it would be most appropriate to use a Poisson regression, but I am unable to perform a Poisson regression, so I will substitute an OLS regression instead.

Chapter 4: Results and Discussion

After collecting my final sample of 153 municipalities, I used SPSS and STATA to employ my conceptual model through several statistical analyses. These included descriptive statistics and OLS regression to see if there were any statistically significant correlations between one or more variables and over compliance.

Table 1 shows a breakdown of the final sampling. Overall, there were 482 reports that had been submitted reports to the Department of Health in 2010. I had initially wanted to collect 241 reports (half of the total reports submitted), but the Partnership for Water Conservation and I were only able to successfully gather information on 153 municipalities, 32% of the total. Of this total, it included those who were non-compliant (did not reach their minimum requirement), complied (met their individual requirement), and over complied (exceeded their minimum requirement) with measure implementation. Almost two thirds of my sample had more than 1,000 connections and were located in Western Washington. There were 52 municipalities engaged in a partnership, and 92 that were over complying, meaning that they implemented more than the minimum number of measures and programs to meet their WUE demand-side goal.

Table 1 - Final Sample Breakdown

	Totals
Total Number of Systems w/ Submitted Reports	482
Total Number of Systems Sampled	153
% Sampled	32%
Systems <1000	58
Systems > 1000	95
East	61
West	92
Partnerships	52
Over compliant	92

After finalizing the sample, I counted the number of measures implemented as reported by each municipality in their annual report to the Department of Health and cross-referenced this information provided in the municipality's individual water efficiency plans (if they were provided). Then I employed my model through an OLS regression to estimate the regression coefficients. Table 3 shows the regression output of my model. The only independent variable showing a statistically significant correlation with over compliance was partnerships at 0.000. There was no other statistically significant relationship with the other independent variables. My model shows the explanatory value, adjusted R^2, as 0.466. Even though this is not as strong of a model, it still shows potential influences on over compliance.

Table 3 - OLS Regression Output

	Coefficient	Std. Error	P > t
Required Measures	0.3268	0.1635	0.048
Population	-1.82E-06	1.17E-06	0.122
Ed. Attain - BA	2.0614	5.8926	0.727
Med. Income	0.0001	0.0007	0.129
East	-0.9059	1.0333	0.382
Partnerships	7.2689	1.1951	0.000
Constant	-1.7244	4.0371	0.670

Discussion

My first hypothesis predicted that there would be a relationship between location and over compliance because Washington State is politically divided and use their water for different uses: Western Washington tends to be more politically liberal and is focused on municipal water supply while Eastern Washington tends to be more politically conservative and water use is focused on agricultural uses. The literature I reviewed had shown a correlation between

environmental consciousness and political attitudes. If one identified as a liberal, a person was more likely to also care for the environment or have stronger environmental values. In this case, as a liberal consumer, one would try to push for more water conservation policies to be implemented where the consumer lived.

One requirement of the WUE is to set a conservation goal through a public forum process, inviting the public to comment and attend this meeting. Presumably, consumers with higher environmental values would be more likely to attend the meeting to voice their opinions about the proposed goals and measures. However, there was no significant relationship between location and over compliance in this data set, meaning that the hypothesis that location would influence over compliance was not supported. The lack of relationship may be due to the individual municipality decision of when to hold the public forum; the time and place may not be conducive for attendance by working individuals or consumer comments are not considered by the MWS management.

My second hypothesis was about a relationship between the size of the system and over compliance. Larger systems can potentially have higher revenue sources dependent on the pricing rate structure implemented. Higher revenue could mean that more money could be allocated towards water efficiency programs and over compliance to the WUE Rule. However, my results showed that my hypothesis about a positive relationship between the size of the system and over compliance was not supported.

Partnerships in my model were shown to have a statistically significant relationship with over compliance (0.00 p-stat value). There were 52 municipalities that are involved or engaged in some type of partnership, which is over one third of my sampling. The types of partnerships included regional programs like the Saving Water Partnership led by the Seattle Public Utilities,

municipality-to-municipality partnerships such as the city of Blaine and Birch Bay Water and Sewer District, or a partnership with non-profit organization, like the Cascade Water Alliance. These municipalities have taken on more stringent and varied measures and programs in comparison to others that do not participate in partnerships. They included measures that ranged from behavioral changes by the customers to public education initiatives to economic incentives (or disincentives through a rate structure).

Because the sizes of the systems varied in these partnerships, it also showed that smaller systems have a willingness to participate in a more stringent set of goals and adoption of measures to meet the overall partnership goals. For example, the smallest system in the Everett Water Utility Committee has 6,233 connections. This number of connections requires the municipality to implement six measures. The largest system in Everett has 63,618 connections, requires it to implement twelve measures. Despite the size differential, both municipalities have over complied by implementing more than required while engaged in their partnership. Because there was a statistically significant relationship between partnerships and over compliance, this hypothesis was found to be supported.

The last two hypotheses were related to the socioeconomic factors of income and educational attainment. Although my literature review implied that demographic characteristics of the community would have an influence on likelihood of over compliance, this study did not show that those characteristics had a statistically significant correlation to over compliance. I did not contact each municipality to gather information on their customers beyond income and educational attainment through Census data. However, if more detailed demographic information were to be gathered about the consumers within the service area, it is possible that other demographic characteristics might be found to have an influence on over compliance.

Income and educational attainment are also highly correlated variables; the higher the educational attainment, the likelihood of a higher income. In order to see the correlations, I ran another statistical test between my independent variables. Table 4 shows the correlation output between my independent variables. The variables of median income and educational attainment (Bachelors) have high correlations (0.7261 and 0.7716) with population, and educational attainment (Bachelors) has a correlative factor of 0.6441 with median income. These highly correlated variables may have potentially over-shadowed a statistically significant relationship to over compliance.

Table 4 - Correlations between Independent and Dependent Variables

	Adopted Measures	Required Measures	Population	Ed Attain: Bachelors	Med. Income	East	Partnerships
Adopted Measures	1.00						
Required Measures	0.4419	1.00					
Population	0.3615	0.4080	1.00				
Ed Attain: Bachelors	0.3353	0.2563	0.7261	1.00			
Med. Income	0.5299	0.4241	0.7716	0.6441	1.00		
East	-0.3921	-0.2609	-0.4187	-0.3648	-0.6253	1.00	
Partnerships	0.6732	0.5084	0.5335	0.4720	0.6756	-0.4434	1.00

Overall, only one out of five hypotheses was supported by my results and that showed that there was a statistically significant relationship between over compliance and partnerships. Although median income and educational attainment were found to be highly correlative (0.6441), neither had any statistically significant relationship with over compliance, Furthermore, neither location of a municipality (west or east) nor the size of the system correlated to over

compliance. There was no clear influence of community individuals on over compliance with the

WUE goals.

Chapter 5: Conclusions

Conclusion

In this study of water conservation in Washington State, municipalities were more likely to be over compliant to the Water Use Efficiency Rule when involved in a partnership because the partnership voluntarily sets higher standards for the entire group than those municipalities that individually implemented measures. This analysis was focused on how the characteristics of the rules and water supply along with attributes of the community can affect the outcomes of over compliance to the WUE Rule. My study shows that there are empirical results that support statements about the positive effects of collaborative environmental management with outcomes of over compliance. Because the sizes of the systems varied in these partnerships, it also showed that all sizes of systems have a willingness to participate in a more stringent set of goals and adoption of measures to meet the overall partnership goals. Collaborative environmental management shows that engagement in a partnership lowers transaction costs when information and resources are shared, making it a win-win solution for all parties involved.

However, there were some municipalities that voluntarily over complied with the WUE Rule even though they were not involved in a partnership. Because I did not individually look at those municipality's specific characteristics, it is difficult to determine a generalized set variables as to why those municipalities voluntarily over complied while not engaged in a partnership. Perhaps those municipalities that chose to over comply had customers, staff members or political boards that wanted to implement more than the required number of measures. On the other hand, the municipality could have implemented a water efficiency program prior to the implementation of the WUE Rule that already exceeded the minimum requirements. Because the existing water

efficiency program already over complied, then the municipality would not have to allocate more funding towards those measures.

My study also showed that there is no relationship between variables like median income, educational attainment, location, or the size of system and over compliance. The independent variables based on demographic information show that they are highly correlative, and therefore, my model may have not been able to show a statistically significant relationship with over compliance. According to my literature review, higher educational attainment lead to potentially higher environmental values which would be reflected in the service area by over compliance by the municipality. A more detailed look at the demographics of the customers in the service area may be needed.

There are policy implications in favor of fostering and engagement of municipalities in voluntary partnerships. My study has shown that those in partnerships are likely to over comply to the WUE Rule, which means more water conservation measures are being implemented than the minimum, and over compliance means that more water is being conserved. This is a huge environmental benefit. Currently, there are several large partnerships exist in King County and Snohomish County and are lead by the Seattle Public Utilities and Everett Regional Water System respectively. These collaborations show that the individually municipalities prioritize water conservation within their own organization and show their support by participating in these partnerships. The Office of Drinking Water should dedicate more resources towards promoting these partnerships as they are successfully complying and over complying with the WUE Rule.

Legislative support through the Municipal Water Law and the Water Use Efficiency Rule shows that water conservation is an important subject that is being addressed now rather than when it becomes a critical problem later. Flexibility of implementation, instead of a prescriptive

set of measures, has allowed each individual municipality to implement the most economically and politically feasible solutions towards reaching their WUE goal. In supporting partnerships through compliance to the Water Use Efficiency Rule, securing future water supplies will become a manageable task for all municipalities through Washington state.

Project Limitations

This study has several limitations that needed to be addressed. These include the sampling, the data collection process, the data, and the type of regression used.

The data from the Department of Health is baseline data, and is incomplete. Not all municipalities completed and submitted their annual reports, and therefore, they were excluded from the sample because their information was unavailable. The data also excludes private water suppliers who were not required to submit a report in the first reporting year. Also, all of this data was self-reported and voluntarily submitted to the Department of Health. Self-reporting likely has inherent human errors, and there is no conclusive way to verify that the information received is entirely correct. By also collecting their Water Use Efficiency plan, I tried to cross-check the information submitted to the Department of Health with what was written in the plan in hopes of finding and correcting these errors.

Definitions including "measures" or "programs" can be interpreted differently by each municipality; municipalities may under-count "measures" or "programs" that may not fit their interpreted definition. They might believe a measure or program would count towards their supply-side goal rather than a demand-side measure. An example of this is replacing meters. Even though this inherently seems like a supply-side measure because it would help a municipality calculate more accurate consumption and calculation of leakage, it also provides

information for a consumer of actual usage. If the usage is high, then a municipality can contact the consumer about the usage or the consumer would naturally reduce their consumption because of a higher water bill.

Since the data collection process was also being done with the Partnership for Water Conservation, multiple people were collecting and extracting information for this study. When the number of people increases during a very specific process like data collection, the more likely for errors as well. Human error may have caused people to overlook or misread information during this process. I was only able to collect 32% of the baseline data, and a large portion of the sample included Western Washington municipalities, including municipalities located in King County. I tried to limit these biases by cross-checking information with the Water Use Efficiency plan and attempted to create a sample without bias, but due to the availability of information and responses, there could be a potential location bias.

Suggestions for Future Investigations

There are several questions that are left unanswered even because my study did not support some of the independent variables like demographics and location. My study only used baseline data from 2009. More data has been collected by the Department of Health, and by July 1, 2012, there should be three years worth of reporting data available to the public. The data that is provided in the reports could be used for a program evaluation on how much water has been saved since implementation or an expansion of my study could be performed to looking specifically at the individual characteristics of the municipalities. A detailed case study between several municipalities could be performed to determine why a municipality chooses to voluntarily over comply or not, interviewing those located within the service area and staff, and

gathering information on the characteristics of the community. A study could be done on the differences between private and public municipalities regarding over compliance or the amount of water saved between the two different types. Another study could be performed on the differences between Eastern and Western Washington municipalities, and more specifically, a comparison of water consumption and conservation between these two locales. Hopefully, if any of these studies are performed, a more generalized set of characteristics may be formed to understand municipalities that voluntarily over comply to the WUE Rule.

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