

UNIVERSITY OF MINNESOTA

# Water Scarcity in Minnesota

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## A Policy Analysis and Recommendation

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Minnesota is facing forces that may lead to water shortfalls across the state. In order to proactively address this detrimental economic and ecological issue, the state government must take action. There are several alternatives that the legislature could use as the basis of new state water policy.

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# Chapter One: Introduction

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*"Anyone who solves the problem of water deserves not one Nobel Prize but two - one for science and the other for peace." President John F. Kennedy<sup>7</sup>*

## Problem Definition

Minnesota may have abundant water but it is not limitless and not evenly distributed across the state.<sup>54</sup> Some areas of the state have limited water resources while others areas have water resources that are plentiful. Despite this disparity, the residents of Minnesota tend to take water for granted. They generally expect to find water available everywhere within the state at minimal cost.<sup>51</sup> The problem that Minnesota faces is some locations within Minnesota may experience shortages of clean water by 2030. What policy changes can the state of Minnesota make in order to bring future water demand in balance with water supply without negatively influencing the state economy and local businesses?

## Purpose of Study

The purpose of this study is to understand how the state government of Minnesota can work with high intensive water users to address growing water demand in Minnesota. There are several needs and rationales for doing this study. One reason for this study is that as water demand increases around the United States, the availability of water may become a major factor in economic decision-making. With this, it is likely that the price of water will rise to reflect its true value.<sup>32</sup> Water is already very important to maintaining the economy. Water is involved with and plays a role in energy production, heavy industry, food production, semiconductor production, and Internet service. Thus, the economy depends on a secure and reliable water supply. As population increases, water consumption will increase. It is a positive feedback loop and may be the main reason for new water demand in the United States. For example, between 2000 and 2007 the population of the United States increased from 285 to 300 million. This increase will continue as the population increases. The population of the United States is expected to grow by at least 120 million by midcentury.<sup>24</sup> Water may be in higher demand and may be under increasing threat from pollution. People may suffer from increasingly severe periods of flood and drought. A safe and adequate water supply is the concern and responsibility of everyone.<sup>7</sup> There is one report that clean groundwater is already becoming scarce in Minnesota and water shortages may continue to be an issue as climate change and other water scarcity issues in the United States worsen. It would be beneficial for the state and its residents to proactively deal with this problem and prevent any potential water shortfalls.

## Evidence

### Water Trends

#### *The Need for Water*

The World Watch Institute has declared that "water scarcity may be the most underappreciated global environmental challenge of our time."<sup>4</sup> According to the United Nations, water scarcity is defined as "as the point at which the aggregate impact of all users impinges on the supply or quality of water under

prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully.” The United Nations believes that water scarcity occurs when annual water supplies are less than 1,000 m<sup>3</sup> per person.<sup>53</sup> Another indicator of scarcity is determined by the Withdrawal to Availability indicator. The indicator is defined as the “ratio of annual water withdrawals to annual water availability and uses threshold levels to define levels of stress.” Unfortunately, the Withdrawal to Availability indicator is not always accurate due to issues surrounding data collection.<sup>1</sup>

Water is absolutely necessary for the survival of most forms of life. Specifically, humans need at least three gallons of drinking water per day in order to survive.<sup>20</sup> Sixty six percent of people in the world may not have enough clean water by the year 2025. By 2050 there may be an additional three billion people trying to access the same amount of water that we use today.<sup>4</sup> Population growth may lead to higher demand for water and may contribute to increasingly scarce supplies of water.

As the population expands, water continues to become more polluted. It is impossible to actually ‘run out’ of water. However, it is possible to run out of clean and easily accessible water. Part of this problem is that about 98 percent of the water on the earth is saltwater. Thus, the amount of freshwater that is easily available for human consumption is about 0.0007 percent of the total amount of water on the earth.<sup>37</sup> The scarcity of freshwater is a problem because the average human needs 13 gallons of water per day for a combination of drinking, cooking, and sanitation. However, citizens from developed countries use much more than that, nearly 160 gallons a day. For example, a baby born in a developed country uses seventy times more water than a baby that is born in a developing country.<sup>4</sup>

Americans do not seem to recognize that they are both contributing to and affected by freshwater scarcity. The biggest way that each person individually contributes to water scarcity is through waste management. Americans use more water flushing toilets than bathing, cooking, or washing dishes and clothes.<sup>21</sup> In the United States specifically, the availability of freshwater across the country is varied. In general, the eastern half of the country is humid and has reasonably reliable access to freshwater. Conversely, the western half of the country is dry and access to freshwater is comparatively difficult. In the western United States, rainfall is scarce. Thus, groundwater aquifers are traditionally used for freshwater supplies. These supplies are overused and increasingly at risk.<sup>20</sup>

### *The Changing Hydrologic Cycle*

Water itself is not becoming more scarce. Instead, there is a higher demand for it. Compounding the problem, water is moving from its traditional sources such as aquifers into sources that humans cannot easily utilize such as oceans.<sup>21</sup> Water is mobile, unlike many other traditional natural resources. It falls from the sky, it flows downhill, it evaporates, and it seeps into the ground.<sup>41</sup> The world's population is continuing to increase, but the amount of clean water that is available is not increasing with the population. The earth still has the same amount of water, but it is not always where it is needed and it is not always in a usable form. Unlike other products, there is truly no substitute for water.<sup>32</sup>

There are several ways in which climate change specifically affect freshwater sources. As seas rise, saltwater will likely destroy low lying wetland areas in coastal regions. This may affect sources of freshwater since wetlands filter and purify dirt and toxins before they reach rivers, lakes and aquifers.

Climate change is also accelerating drought and causing more extreme storms and weather patterns. Annual rainfall will likely decline in areas that are already dry and salinity and desertification may spread as water evaporates more quickly from the soil.<sup>4</sup> Water in lakes and rivers may also evaporate more quickly and the snowfalls that replenish these systems may decrease. Summers may be hotter, longer, and drier, with increased drought frequency.<sup>12</sup> With the decreasing amount of accumulated snowfall, there may be earlier spring melts. Earlier melts may change the seasonal hydrologic cycle in all water bodies. This means that there may be reduced periods of time when lakes and rivers are ice covered and overall lower water levels in these same water bodies.

A large number of the world's population lives in areas where most of their rainfall comes within only a few short months of the year. This influx of rain in a short period of time can lead to intense flooding.<sup>37</sup> At the same time that droughts are increasing across the globe, there may be more precipitation in areas that already receive plenty of rain. Climate change may encourage stronger and more extreme precipitation events. There will specifically be increased thunderstorm activity in late winter, spring, and fall. An increase of rain in an area that already has substantial rainfall may create severe and unpredictable floods. This excess flooding could swamp dams and locks. Some reservoirs may overflow in the early spring, but be dry by late summer.<sup>32</sup> However, a higher probability of rain-on-snow events in late winter could increase the probability of local flooding.<sup>12</sup>

Climate change may specifically have an effect on agriculture. The more intense spring storms may lead to more flooding of rivers and fields. This may interfere with spring planting and may damage young crops. If fields flood during the growing season, crop losses may occur from anoxia and root diseases. If the response of agricultural landowners is simply to increase tile draining, heavy erosion of stream-banks and increased flooding may result. Flooding may lead to increased surface runoff and this runoff may carry more sediment, nutrients, fertilizer and pesticides into streams, lakes and groundwater. The resulting higher runoff velocities may decrease groundwater infiltration and aquifer recharge.<sup>12</sup> This is all likely to contribute to growing water shortages.

Not even the Great Lakes have an excess of water. Although they hold 18 percent of all the fresh surface water on the earth,<sup>2</sup> much of the water that is extracted from the Great Lakes will not return directly to them.<sup>32</sup> This is very destructive to the ecosystem since less than one percent of the water in the Great Lakes basin is renewable. This means that only one percent of the water in the lakes is recharged through the return of water from its watersheds. The other 99 percent of water was deposited by glaciers during the last ice age.<sup>2</sup> In 2007, Lake Superior dropped to its lowest level in eighty years and the water has receded more than 50 feet from the shoreline.<sup>4</sup> Climate change has reduced winter snowfall and increased air temperatures around the lakes. The corresponding warmer water temperatures and shallow water levels have increased evaporation from the lakes. Evaporation is furthering the decrease in water levels, which causes concern for both navigation and the natural environment along the shoreline.<sup>7</sup>

Climate change is affecting Minnesota. In the last few decades, the state has seen increasing air temperatures; the temperature increases have been greatest in the northern part of the state. Also, it is projected that summer rainfall will decrease by about 15 percent. Less rainfall combined with increased

air temperatures could severely stress crops. The summer drought of 1998 in Minnesota resulted in economic losses of \$56 billion for the state. In addition, flood or drought induced changes in water levels can have negative impacts on the shipping industry. Minnesota experienced this during the floods of 1993 and the drought of 1988. Minnesota has already experienced negative economic impacts from extreme weather events. Such events may continue to increase and affect Minnesota due to global climate change.<sup>12</sup>

Changes in the hydrologic cycle due to climate change may increase the extremes of both drought and floods. The projected climate changes are very difficult to predict, especially on a regional scale. Thus, future water shortages are unpredictable and uncertain.<sup>37</sup>

## Consumption

### Energy

Energy use and water are connected on an atmospheric scale as well. In California, the 44 million acre-feet of water that are used annually results in the emission of 44 million tons of carbon dioxide from electricity generation. As a by-product of fossil fuel combustion, carbon dioxide can trap heat in the earth's atmosphere and helps to accelerate climate change.<sup>24</sup> Humanity is in a positive feedback loop. Climate change is reducing water supplies, and the current systems used to deliver clean water and treat wastewater produce the same greenhouse gases that contribute to climatic change.<sup>41</sup>

Water is very heavy; one acre-foot of water (325,724 gal), weighs approximately 1,231 metric tons (2,713,890 lb.).<sup>35</sup> Thus it takes considerable energy to move it. Pumping it from the ground and transporting it through canals and pipes require a substantial amount of energy.<sup>24</sup> It takes a substantial amount of water to produce energy and it takes a lot of energy to treat and deliver water. This problem is exacerbated because the availability of both energy and water is limited.<sup>32</sup> The 60,000 water systems and 15,000 wastewater systems in the United States use approximately 75 billion kilowatts per year of electricity - about four percent of the nation's energy consumption. A great deal of energy is required to pump, transport, treat and distribute water and to collect and treat wastewater.<sup>24</sup> In 2006, the Department of Energy estimated that four percent of total United States electricity use goes to power the water cycle.<sup>1</sup> In California specifically, moving water is the state's single greatest use of energy. California uses 19 percent of its electricity, 32 percent of its natural gas, and 88 million gallons of diesel per year to convey, treat, and distribute water and wastewater.<sup>41</sup>

Power generation accounted for slightly more than 59 percent of the total water used in Minnesota in 2007.<sup>54</sup> United States power plants use 201 billion gallons of water in the course of generating electricity. Water is used by coal, gas, and nuclear power plants for cooling and to make steam. These electric utilities require seven times more water than all residential homes. They use 1.5 times the amount of water used by all the farms in the country.<sup>21</sup> As population grows, water demand for power generation is steadily increasing, although this may be offset in the future by greater use of solar or wind power generation.

An important distinction between industrial and agricultural water use is the difference between consumptive and non-consumptive uses of water. Thermoelectric power generation uses a huge

amount of water, but most of that use is for non-consumptive cooling purposes. In other words, the majority of the water that is withdrawn from a water source, such as a river, and just passes through the plant for cooling. It is then returned back to the original water source.<sup>32</sup> There may be a net loss of volume, but power plants believe that this loss is very minor. However, other sources state that the consumptive use of water in energy production exceeds one-quarter of all nonagricultural water use.<sup>24</sup> The returned non-consumptive water may be warmer or changed somewhat chemically; it is this lesser quality water that is available for another use downstream. However, when groundwater is used for power generation, the water use is considered consumptive because the water is not directly returned to its original aquifer source.<sup>54</sup>

Water is also critical for the energy industry in order to mine, refine, process, and transport fossil fuels such as oil, natural gas, and coal. It takes up to 2.5 gallons of water to refine one gallon of petroleum. It takes up to 0.7 gallons of water per kilowatt to make electricity from a coal-fired power plant. A typical 1,000 megawatt plant consumes 10,000 gallons of water a minute through evaporation. One 60-watt light bulb that burns for twelve hours per day consumes up to 6,000 gallons of water per year.<sup>24</sup>

Water is also used in the production of ethanol. Producing one gallon of ethanol requires five gallons of water. Thus, a facility producing 47 million gallons of ethanol per year uses as much water as a city serving 7,000 people.<sup>54</sup> In Minnesota, there are 21 ethanol plants that can make 1 billion gallons of ethanol. This contributes over \$2 billion annually to the state economy and has created over 4,300 jobs. Ethanol production should stay high since 20% of gasoline must be comprised of ethanol in 2013.<sup>33</sup> In 2006, Minnesota ethanol production will require about 2.5 billion gallons of water. This is more water than is annually used by Washington County, which is the county seat of Stillwater MN and home to almost 240,000 people. If ethanol production continues to expand, this use may be significant in locales with ethanol plants because these facilities use water year-round and water levels in the aquifer have no time to recover.

The Granite Falls Energy plant began producing ethanol in late 2005. The refinery was designed to produce 40 million gallons of ethanol per year. Granite Falls Energy needs nearly 400 gallons of water per minute to operate their ethanol plant. That is 160 million gallons of water per year. Water levels in the source aquifer declined steadily and then well interference problems with domestic wells over three miles away began to occur.<sup>55</sup> Many domestic wells had gone dry and their pump motors had burned out. Angry well owners forced Granite Falls Energy to divert water from the Minnesota River instead of using the underlying aquifer. However, if a drought occurs, the Minnesota Department of Natural Resources will order Granite Falls Energy to halt the diversion.<sup>24</sup>

### *Industrial Uses*

One of the biggest uses of water in many factories is for cooling. Water can easily remove heat from a newly minted ball bearing, baby bottle, or baseball bat. Often the water used for cooling never even touches the product. Instead it flows through the necessary machines in order to lower the temperature. Technically, if the water is only being used to lower the temperature of a machine, the same water could be reused.<sup>54</sup> Because of certain regulations and higher prices of water, many factories have begun to use a system of water recirculation in order to cool their products. This involves using the same parcel of cooling water repeatedly. However, there have been some studies that suggest that recirculating cooling

actually has a higher consumptive water use despite the fact that it has lower water withdrawals. Specifically, a study done by Dziegielewski and Bik calculated that “the average fossil fuel plant with once-through cooling consumes 0.2 gal/kWh, while recirculating systems consume 0.7 gal/kWh.”<sup>1</sup>

There are other problems with recirculation and reuse as well. For example, a small Swiss manufacturer, Rohner Textil, designed a closed-loop water system to recycle water. However, the new system significantly increased energy use and eliminated any economical savings.<sup>19</sup> Also, in many reuse and recycling systems there would need to be a place to store the water in order to let it cool, which can have an expensive initial cost for investment. Presently, water storage is only feasible when high water prices are involved.<sup>32</sup> Other industrial processing also uses water, including mining activities and paper mill operations. Industrial processing used 12 percent of the total Minnesota state water use for 2007.<sup>54</sup>

In the United States, water is scarce in the Southwest. But places where water is abundant, like Oregon, Milwaukee, and Buffalo can handle both a growing population and growing industries without depleting their supply of water. A big problem in the United States is that the population and economic centers of today are not always located where there is abundant water.<sup>32</sup> In California, one acre-foot of water that is used to grow alfalfa generates \$60 in revenues. The same amount of water used to make semiconductors generates nearly \$1 million.<sup>24</sup> Similarly, the availability of water is one of the reasons that Oregon is an attractive place to locate data centers. The abundance of water in this state is used in evaporative systems to cool down the thousands of computing devices inside the data center. Facebook and Google are both building massive data centers in Oregon. The city of Milwaukee wants water intensive industries to move to that city and is correspondingly building a sustainable water infrastructure. A manufacturer of water meters, Badger Meter, in the area is promising cheap or even free water. This company believes that cities such as Milwaukee could attract a number of water intensive businesses. In other words, in the future, high-growth industries may start to seek out cities like Milwaukee simply because of the availability of inexpensive and abundant water. City leaders from Milwaukee have declared it their mission to become the “world's water hub for research, economic development, and education.” The city has already seen growth in the data center industry.<sup>32</sup>

Water may increasingly be viewed as a factor of production - like energy, labor, or capital - in manufacturing, policymaking, and economic decision-making.<sup>32</sup> Major industrial operations have traditionally ignored the cost of water when deciding where to locate manufacturing facilities. Traditionally cheap labor and energy sources have been the priority. However, as water prices rise, industry operations that use a substantial amount of water may need to begin to be located in areas of more plentiful water.

### *Agriculture*

As populations around the world increase, more crops may need to be grown in order to feed the people of the world. In most areas of the world, food crops can only be grown on a large enough scale if irrigation is used.<sup>19</sup> Depending on the region, irrigation uses water withdrawn from either surface water or ground water sources. Much of the irrigation that is needed to grow crops in Minnesota is on such a large scale that farmers must obtain water permits from the Department of Natural Resources. Of 7,000 active water appropriation permits in Minnesota, 73 percent are for irrigation. Of the permits that were issued for irrigation, 89 percent of those permits used water from ground water resources.<sup>54</sup> In total, up

to 40 percent of the water used for the agricultural industry comes from groundwater in the United States.<sup>43</sup> In Minnesota, 18% of consumptive water use is for agricultural use.<sup>35</sup> Although water use for irrigation can vary from year to year due to weather patterns, the most recent Environmental Quality Board report indicates that total annual demand for water in Minnesota grew 18 percent between 1995 and 2005. Since per capita use only grew six percent during this same time, it is likely that agriculture is a factor in this growth.<sup>30</sup>

Everyone needs food to survive. It takes a great deal of water to grow crops and to manufacture them into popular foods. One glass of beer = 20 gallons of water. One cup of coffee = 37 gallons of water. One gallon of milk = 53 gallons of water. One pound of cheese = 371 gallons of water. One pound of chicken = 469 gallons of water. One pound of pork = 756 gallons of water. One pound of beef = 1857 gallons of water. Corn is the most widely grown grain in the United States. Over 80 million acres of land are planted with corn in the United States. Much of this crop is used as a livestock feed and contributes to the water needs of the above products. Corn is also an ingredient in products such as starch, sweeteners, corn oil, beverages and industrial alcohol, and fuel ethanol.<sup>32</sup>

A farmer in Minnesota who made \$27,000 raising 1000 acres of corn in 2004 made a profit of \$270,000 in 2007.<sup>24</sup> Water provides \$9.3 billion in farm income each year and generates \$55 billion in economic activity in the state.<sup>35</sup> Protecting existing farmland is critical for the nation's economy and food supply, national security, the fiscal stability of local governments, and even the environment because farmland provides open space, food and cover for wildlife, flood control, and wetlands protection.<sup>24</sup>

### Minnesota's Issues

Minnesotans pride themselves on clean and abundant water resources. Water provides Minnesotans with jobs, increases the quality of life, supports fish and wildlife and provides options for a \$10 billion dollar recreation and tourism industry.<sup>49</sup> Water is necessary for a healthy Minnesota economy, healthy ecosystems and a high quality of life. Minnesotans truly value their water resources. Citizens believe that the most important use of water is for drinking water and ecological services. In order to ensure adequate clean water for all people, water needs to become a global priority; it is necessary for the continuation of neighborhoods, communities, economies, environment, and continued human existence on this planet.

### Demographics

With increasing population and economic growth, it is important to understand where water may be sufficient to meet future demands and where it may not.<sup>50</sup> Ultimately, the key to water management is to have enough water of the quantities desired for the intended use at the location where it is needed now and for future generations.<sup>51</sup>

The state's population in 2010 was estimated to be about 5.4 million people. Approximately four million of these citizens live in one of the metropolitan areas, including Minneapolis – Saint Paul, Duluth, and Rochester. Minnesota's population is expected to grow to 6.3 million by 2030. Of this, Minneapolis - Saint Paul will add nearly one million people. Water use is also growing 1.6 times faster than population growth. This means that the state would need to reduce water consumption by 35% over the next 25 years just to stay at today's levels of use.<sup>35</sup> Median household income, an indicator of both demand and

ability to pay for water varies greatly between urban and rural areas. Among Minnesota counties in 2007, estimated median household incomes ranged from \$34,503 in rural Clearwater County to \$80,038 in urban Carver County. The Twin Cities area will have the highest demand as well as the highest ability to pay for water. Thus, they may have a greatest ability to manage impacts.<sup>30</sup>

Overall, Minnesota saw water use increase by 77.6 billion gallons per year from 1999 through 2008.<sup>14</sup> Urban populations specifically place large demands on water supply, wastewater disposal, energy and industrial production, water related recreation, and ecological services. Minnesotans used 128 billion gallons of drinking-quality water in 2005.<sup>35</sup> Nearly half of the water will need to be distributed to residential users. One third of the water is for water treatment projects. The remaining one fifth of the cost is for storage facilities and development of supplies. The cost of drinking water added to the costs for wastewater, storm water, and drinking-water infrastructure approach \$12 billion.<sup>30</sup>

### *Water Use*

In Minnesota, any water user withdrawing more than 10,000 gallons per day or one million gallons per year is required to obtain a water use permit from the Minnesota Department of Natural Resources. From 1991 to 2005 water permits increased from 1.1 trillion gallons to 1.4 trillion gallons a year.<sup>22</sup> The largest category of permitted water use in the state is for electric power generation. Municipal water supply systems are the second-largest category of permitted users. Industrial processes such as mining, papermaking, and food processing also use large volumes of water. Finally, irrigation and other agricultural uses represent the fourth major category of permitted water use.<sup>28</sup> Smaller withdrawals, such as wells for rural domestic use, do not require permits, even though their cumulative impacts may be significant. Waste disposal, ecological services, and recreation also place large demands on Minnesota's water resources, although they also do not require permits.<sup>30</sup>

Typically, residential water users in Minnesota consume 75 gallons per person per day. Minnesota citizens that live in metropolitan areas use about 2.5 times more water on the peak summer day than on an average day in order to water their lawns. Larger volumes of water are also withdrawn for activities including air conditioning, construction dewatering, water level maintenance, and pollution confinement.<sup>54</sup> This need to meet peak demands in use can lead to costly construction of new municipal wells, as well as treatment and storage facilities. More importantly, increased peak usage depletes the water supply more quickly.<sup>51</sup>

A rapidly growing population, increased water consumption rates, and emerging water demands challenge the ability to maintain adequate water supplies for Minnesota's people and their habits. Between 1995 and 2005, water use grew 50 percent faster than population. The state may need to act strategically to ensure sustainable water use to meet the needs of an increasing - and increasingly demanding - population.<sup>49</sup> Water use is continuing to grow faster than the population: Minnesota water use has increased by 24 percent over the last 20 years as tracked by the Department of Natural Resources through the water permit program, while the population has increased 22 percent.<sup>54</sup> Not only is Minnesota's growing population demanding more water services, but it is also demanding more energy, which in turn requires more water.<sup>17</sup>

### *Water Supply*

Glacial activity made Minnesota one of the most water rich states in the continental United States. The headwaters of the three largest drainage basins in the North American continent can be found in Minnesota, including the Mississippi river, the Great Lakes, and the Red River of the North, which eventually becomes the largest tributary to Hudson Bay.<sup>44</sup> Minnesota's 1,919 mile border is 67 percent surface water. The state shares its border with five states and two Canadian provinces.<sup>31</sup> Minnesota has more than 13.1 million acres of water, including lakes, wetlands, and rivers. Minnesota has about 105,000 stream miles, which are distributed among 81 major watersheds, and about 9.3 million wetland acres. Of Minnesota's 12,200 lakes, 800 are greater than 500 acres, 4,000 are between 100 and 500 acres, and the remaining lakes are between 10 and 100 acres.<sup>26</sup>

Although part of Minnesota is adjacent to Lake Superior, most of Minnesota does not rely on the Great Lakes for water. The Great Lakes Compact, which was signed by the governors of the Great Lakes states in late 2005, is an agreement that was made to protect the Great Lakes. It declares that the waters of the basin "are public resources held in trust."<sup>13</sup> The agreement is an international commitment between the states and provinces that surrounds the Great Lakes. The compact is designed to coordinate the sustainable management of the regional water supply.<sup>2</sup> The citizens that live in the Great Lakes basin are very worried about losing the water in the Great Lakes. However, the real threat to draining the Great Lakes comes not from far away states, but comes instead from neighboring states and cities that are located just outside the Great Lakes Basin.<sup>24</sup> For example, there have been several proposals from areas just a few miles outside of the lake drainage area. Such proposals, like ones to use water to process corn into ethanol, have so far been denied.<sup>32</sup> In conclusion, although the Great Lakes seem to have an abundance of fresh water, citizens that live in the area have both pride for the lakes and fear of water demands from outsiders. Due to this compact it is very unlikely that the Great Lakes will be a solution for increasing water demand across the globe.

Surface water provides water for approximately 20 percent of Minnesota's Department of Natural Resource water permits.<sup>54</sup> A main source of surface water is precipitation.<sup>31</sup> Thus, surface water may become slightly more scarce because it is expected that there will be a decrease of six percent in average annual precipitation in Minnesota. This decrease in precipitation will mainly impact the southwestern region of Minnesota.<sup>23</sup> This is important for two reasons. First, precipitation makes up 99 percent of the water that enters Minnesota.<sup>35</sup> Second, ground water is another major source of surface water.

Groundwater provides drinking water for at least 75 percent of its population.<sup>45</sup> Some estimates put it as high as 90%.<sup>22</sup> Despite the large use, there is still uncertainty about how much water actually exists in Minnesota. Minnesota's complex systems of layered aquifers have not been fully quantified.<sup>49</sup> This is especially true because the current non-aquifer formations are not being completely monitored. Also, not all counties have monitoring wells due to low population levels.<sup>36</sup> However, the aquifers that have been quantified have been shown to be declining.<sup>14</sup> Ground water is available everywhere beneath Minnesota, but useable amounts are not evenly distributed due to Minnesota's varying geology.

When groundwater is used more rapidly than it is being recharged, water tables fall over time, which can lead to a variety of problems. Even in regions with relatively abundant water, there are consequences for water withdrawal from aquifers. These consequences include reduced groundwater discharge to lakes and rivers. This reduced discharge may have corresponding impacts to aquatic life, ecosystem and human health, water contaminants, and financial burdens associated but not limited to building new and deeper wells and infrastructure.<sup>51</sup> Also, more energy must be used to pump water from these deeper wells. It is also possible that land may collapse when water is pumped out. Such subsidence can lead to water pipes bursting and additional water being wasted. Additionally, a hydraulic gradient could be created, drawing in potential contaminants from nearby sites.<sup>1</sup>

### *Water Availability in Minnesota*

The label of Minnesota as water rich does not fit as well as once thought. Minnesota may have abundant water but it is not limitless and not evenly distributed across the landscape.<sup>54</sup> Some areas of the state have limited water resources while others areas have water resources that are plentiful. Despite this disparity, Minnesota culture tends to take water for granted. Residents of Minnesota generally expect to find water readily available everywhere within the state at minimal cost. The problem is that an increasing number of Minnesota locations are experiencing water supply problems related to inadequate supplies.<sup>51</sup>

Water availability problems are most evident in places where water is being consumed faster than it can be replenished, such as in metropolitan areas.<sup>51</sup> In the metropolitan areas, the population density strains the resources and sometimes there is not enough water to sustain high volume users.<sup>49</sup> The area from south of the Twin Cities to St. Cloud already makes significant demands on its renewable water resources.<sup>50</sup> For most of Minnesota's history, urbanization has had no regard to the impacts on water resources. Water was always assumed to be available and was withdrawn from surface water and groundwater systems with little thought to sustainable use.<sup>30</sup> Even presently, thoughts about sustainability generally only happen during a drought, which Minnesota generally experiences every five to ten years; after the drought ends, interest in water conservation quickly ends.<sup>17</sup>

Historically, Minnesotans have spent a great deal of time and energy in attempting to rid the landscape of water, in order to increase agricultural yields. This longstanding perception of excess water has affected public understanding regarding the need to conserve. In 2008, the Environmental Quality Board found that "the state does not collect or process sufficient water-related information to know with certainty overall whether it is managing water resources sustainably."<sup>55</sup> The board noted that "the state has only recently begun to consider whether its water supplies are sufficient to meet the long range seasonal requirements of communities, businesses and ecosystems."<sup>55</sup> Minnesotans can expect any water-related problems that they currently face to increase in severity and complexity as the state's people, economy, and communities expand.<sup>55</sup>

For example, the city of Ramsey faces future water shortages and may not be able to meet demands with groundwater alone. Thus, community leaders are considering options to finance a treatment plant that can draw water from the Mississippi River.<sup>49</sup> The availability of urban water resources is far from assured and any disruption of water availability would likely affect Minnesota's economy.<sup>30</sup>

Although unsustainable groundwater use was only documented, and is disputed, in one study, this study cannot be taken lightly. In 2005, seven counties used over 40 percent of their renewable water resources and each one was a part of the Twin Cities Metropolitan Area. Although at that time, only Ramsey County used more than 100 percent of its renewable groundwater resource, 135 percent. However, in 2030 this study estimated that at least four counties will be at or above 100 percent use of their renewable groundwater resources. In 2030, Ramsey County will be using 177 percent and Washington County will be using 172 percent of its renewable water resources. Dakota and Hennepin counties will be using 99 percent of their renewable water resources.<sup>50</sup> This means that more water is demanded from the county's "home grown" supply that is available long term. Reserves may be being pumped out of aquifers faster than they can be replaced. These facts led the Environmental Quality Board to conclude that "the label of Minnesota as water rich does not fit as well as once thought. The growth corridor from south of the Twin Cities to St. Cloud already makes significant demands on its renewable water resources, making water supply management a special concern."<sup>50</sup> Stated another way, meeting the growing demand for water in Minnesota may be increasingly difficult, especially in the rapidly urbanizing metropolitan areas.<sup>30</sup>

Though the study that is cited above is disputed, it is possible that the results of this study could come to pass by 2030. By using the precautionary principle, Minnesota may be able to proactively prevent any damages from potential shortfalls of clean water. Water quantity is regulated by many different state statutes and departments; there is no one overarching water policy that governs the entirety of water within the state of Minnesota.<sup>44</sup> It can be difficult to manage a resource that is out of sight and has long time constraints over which changes are noticed.<sup>45</sup> Thus, policies such as funding levels are inadequate to meet the growing demands for urban water infrastructure. This is a growing problem as urban populations increase and old water systems deteriorate. Two additional factors may encourage Minnesota to make water scarcity management and policy a high priority. First, both the population and demand for water is growing. Second, climate change may make water management more difficult. Many changes in precipitation, snowfall, and droughts may be unpredictable hence planning for water usage may also be difficult.<sup>16</sup>

# Chapter Two: Literature Review

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*"When the well's dry, we know the worth of water," observed Benjamin Franklin in 1774. But he was wrong. In the United States we utterly fail to appreciate the value of water, even as we are running out.*<sup>24</sup>

## Introduction

### Opening

Over two-thirds of the water used in the United States is used for irrigation. Nearly 50 percent is used for thermoelectric power. Nearly 11 percent of water used is for the public utility supply and nearly five percent is for industrial uses.<sup>32</sup> Water is special. In most situations, a person can survive without a certain good or obtain a substitute for that good. However, one cannot do without or substitute water for most uses. In terms of drinking and general water for living, most people have few alternatives. There are also many businesses that cannot do without or substitute water.<sup>20</sup> Water may become a limiting factor in many areas of the world in terms of future manufacturing, energy, and industrial production.<sup>32</sup>

Taken as a whole, water is probably the world's third largest industry. Some of the water industry sectors include: include water treatment equipment makers; pump, valve, and pipe manufacturers; water engineers and plant designers; water testing laboratories; monitoring equipment manufacturers; contractors that dig trenches, install pipes, and pave streets; and manufacturers of treatment chemicals. This would place the commercial water market at around \$600 billion per year worldwide. It will almost certainly continue growing for a long time into the future.<sup>32</sup>

The amount of water that it takes to produce \$100 worth of alfalfa can produce \$5 million worth of computer chips. That is enough revenue to provide dozens of jobs, and it may even leave a little left over for more local watershed protection, environmental restoration projects, and research into further water conservation measures. Intel in 2008 pledged to spend \$100 million to do just that, and has an entire division devoted to reducing water use. Private firms are jumping over one another to enter the water business, to help solve some aspect of the water challenge, to 'well by doing good.'<sup>32</sup>

### Research Problem

The problem that Minnesota faces is that an increasing number of locations within Minnesota are experiencing shortages of clean water. In Minnesota's Twin Cities region, residents support the increased protection and preservation of important natural resource areas. In the Metropolitan Council's 2001 Survey of Metro Area Residents, 93% of respondents agreed or strongly agreed that "as areas develop, governments should do more to protect natural features, such as lakes and rivers." It can be extrapolated that if polled, the respondents would likely include aquifers in that statement. The council is making efforts to protect the resources in the region. Specifically, its plan includes meeting the needs of current and future residents, using land sensibly, and protecting the region's prized natural environment. The corresponding policy states: "work with local and regional partners to reclaim, conserve, protect and enhance the region's vital natural resources."<sup>43</sup> This study would expand on the

Metropolitan Councils work. Specifically, what policy changes can the state of Minnesota make in order to bring water demand in balance with water supply without negatively influencing the state economy and local businesses?

### Outline for Literature Review

There are five main areas of alternatives related to the research from chapter one. The five main areas of review include Minnesota water law, Minnesota water governance structure, water permits in Minnesota, water pricing options in Minnesota, and other potential policy options for Minnesota. There are also several potential policy alternatives that could encourage water conservation in Minnesota. These alternatives are not mutually exclusive; rather, they represent a menu of options available to policymakers in any number of combinations.

The first literature that needed to be reviewed was water law and management in Minnesota. For this analysis, several different books were consulted, as listed in the footnotes. Water law needed to be reviewed because one must understand the overarching law; current water law in Minnesota is a regulated riparian system. Further academic research should be done on whether or not this system should be altered to help Minnesota conserve water. Also, it would be beneficial for further research to be done to determine what stakeholders would be benefited from a change in this system.

The second area of literature that required review was the current holistic state governing system of water. In order to garner any solutions, one must understand the role and purpose of officials throughout the state. Understanding the current system helps one to understand what water management techniques in the state currently work well, and which management techniques do not work well. State governance of Minnesota's water is very scattered. Currently, no single state government agency has the responsibility for coordinating or overseeing management of Minnesota's more than 12,000 lakes and miles of rivers. This allows for a number of overlapping policies and also many gaps in policy. Academics should also evaluate whether or not Minnesota should alter its governance structure in order to have a more holistic management system for water. It also needs to be determined how an alteration of this magnitude would affect the economy of Minnesota and Minnesota businesses.

The third area of literature that was reviewed was about the Department of Natural Resources water permit systems. A number of books and articles were cited and consulted in this research, as noted by the footnotes. The Minnesota Department of Natural Resources is in charge of allocating and revoking water permits in Minnesota. Because it regulates the amount of groundwater and surface waters that individuals and firms can extract, it is a highly integral part of the water management system in Minnesota. Changing the permit system in Minnesota may help water conservation from industries that are located in the state. Further research on the benefits and detriments of changing permitting policy for the goal of conserving water would be beneficial. Additionally, before changes are made the state will need to know how high water use industries will react to these changes.

The next issue that needed to be reviewed is potential water pricing options. Currently the cost of water only takes into account extraction and infrastructure costs. The true cost of water is much higher when one takes scarcity into account. Water needs to be appropriately priced in Minnesota in order to maximize efficiency while minimizing externalities. Solutions used in other states include taxes, quotas,

alternative water pricing structures, and subsidies for efficiency implementation. Research into what pricing options would be the best to conserve water and yet not unduly punish high water use businesses, would be beneficial.

Currently a great deal of water is wasted in Minnesota. One of every six gallons of water pumped into water mains by United States utilities simply leaks away, back into the ground. Sixteen percent of the water disappears from pipes before it makes it to a home or business or factory. Every six days, United States water utilities lose an entire day's water.<sup>21</sup> Also, most wastewater generated along the coasts ends up in the ocean, even though it is treated to near potable standards. Investing in infrastructure or water recycling programs can be highly effective means of conservation. However, these are very expensive. The state will need to evaluate whether or not it can afford to make these retrofit changes. If it cannot, the state will need to determine how businesses can help to bear the cost without driving them out of business or to other states.

The best solution to solving Minnesota's water demand and potential supply problems is to have a policy that addresses water holistically. All of the above problems should be addressed in some way in order for the problem to be solved in the best possible way. There are a number of studies that have been done addressing how to conserve water in the United States. Law, the governance structure, pricing, and infrastructure options are all ways to conserve water. However, none of the solutions in the literature have been proactively implemented in the middle west of the United States. Thus, research must be done on how businesses and the state government of Minnesota can agree to proactively implement measures to protect Minnesota's water's without putting the burden of cost unduly on any one stakeholder.

## Body of Review and Alternatives

### State Governing

#### *Current Law*

The first literature that needed to be reviewed was water law and management in Minnesota. For this analysis, several different books were consulted, as listed in the footnotes. Water law needed to be reviewed because one must understand the overarching law in order to make any future changes to it.

There are over a dozen federal departments and agencies that manage water waste water, and related issues, such as energy.<sup>41</sup> In the United States, groundwater management decisions are made at a local level, not at the federal level.<sup>43</sup> Each state preserves waters for certain designated uses.<sup>13</sup> Every state has various governmental departments that administer water resources programs. State water agencies administer water quality programs, flood protection, drought planning, water allocation, and conservation efforts on a statewide basis. Municipal water departments provide drinking water to residents.<sup>7</sup>

Minnesota water law is a regulated riparian jurisdiction. Minnesota has modified traditional riparian rights by overlaying a legislatively enacted administrative permitting and regulatory scheme. In Minnesota, both surface waters and groundwater resources are owned by the state in its sovereign capacity as trustee for the benefit of the public. Individuals, municipalities, corporations, and other legal

entities do not own water outright. Instead, they hold rights to use water for certain purposes, subject to state supervision and regulation. Specifically, Minnesota claims public ownership of the beds of lakes or streams that are determined to be 'navigable-in-fact.' This means that they are able to be used in their ordinary condition as "highways of commerce over which trade and travel are or may be conducted." Riparian landowners may not drain, dike, or fence off their portion of a water body or otherwise deny surface use to other persons who have legally gained access. All riparian landowners have equal rights to use a lake over its entire surface, regardless of who owns a particular part of the lakebed.<sup>28</sup>

Minnesota's water law is a curious hybrid, with an administrative permitting scheme (discussed later) for large scale water appropriators sitting uneasily atop an essentially unmodified riparian rights scheme for small scale riparian users. If water becomes scarcer, either in an absolute sense or relative to growing demand, then the two may come increasingly into conflict, and legal adjustments may be required.<sup>28</sup> In conclusion, Minnesota's water law is similar to the water law of other eastern states. However, this type of regulated riparian system is still complex and unwieldy.

### *State Departments*

The second area that needed review was the current holistic state governing system of water. The Minnesota legislature recently passed legislation requiring planning for 'sustainable water use' defined as use that "does not harm ecosystems, degrade water quality, or compromise the ability of future generations to meet their own needs."<sup>34</sup> The Minnesota legislature defines sustainable as "when the use does not harm ecosystems, degrade water quality, or compromise the ability of future generations to meet their own needs."<sup>44</sup> Minnesota Statutes, section 4A.07 defines sustainable development as "development that maintains or enhances economic opportunity and community well-being while protecting and restoring the natural environment upon which people and economies depend."<sup>50</sup>

The state of Minnesota is currently able to meet basic human needs for water in Minnesota, ensure that water remains an important economic asset, slow and sometimes reverse many destructive water use trends, and maintain a high level of technical expertise. This is all done through a myriad of different departments. No single state government agency has the responsibility for coordinating or overseeing management of Minnesota's more than 12,000 lakes. Not surprisingly, the role each agency has played has changed in response to new problems. The Department of Natural Resources deals with allocation of water use within the state. The Pollution Control Agency protects, improves, and restores water quality and is responsible for the feedlot and impaired waters programs, acid precipitation, clean-water monitoring, storm water and septic system standards, and leaking landfills and underground storage tanks. The Department of Health administers the Safe Drinking Water Act in public water supplies, regulates wells and borings, protects source water and wellheads, establishes groundwater health risk limits, and is responsible for public health safety in administering the federal Safe Drinking Water Act. The Board of Water and Soil Resources provides technical and financial assistance to local units and landowners on water resource concerns, for comprehensive local water planning, and for wetland management and protection. The Department of Agriculture assists farmers with best management practices for water quality and integrated pest management and regulates pesticide control. The Environmental Quality Board, composed of representatives from the state agencies with environmental

responsibilities along with five citizens, provides for environmental review oversight, is responsible for overall state water-planning coordination, makes water policy recommendations, and develops a state water plan. The Minnesota Public Facilities Authority, Department of Transportation, and Department of Public Safety also have programs relating to water.<sup>27</sup>

Minnesota fails to take a holistic approach to its use and management of water, with numerous state agencies in charge of different aspects of the state's water resources. This makes for fragmented, overlapping, and duplicated policies.<sup>35</sup> Water monitoring, which is now spread among at least five state agencies, could be consolidated under one agency for better focus and ease of data collection.<sup>27</sup> Minnesota may find it valuable to proactively evaluate its water resources and manage them for future growth. For example, the two largest water suppliers in the metropolitan region, the city of Minneapolis Water Works and the St. Paul Regional Water Services are not interconnected. Since the 1930s, officials in both cities have sought to connect the two systems to provide ongoing, emergency water to one another, especially during peak demand. While both systems are well suited to supplement the needs of the other, they simply lack the facilities to transfer the water.<sup>49</sup>

### *Water Permitting*

The third area of literature that was reviewed was about the Department of Natural Resources water permit systems. A number of books and articles were cited and consulted in this research, as noted by the footnotes. The Department of Natural Resources is responsible for water appropriation in Minnesota. Because they regulated the amount of groundwater and surface waters that individuals and firms can extract, they are a highly important part of the water management system in Minnesota.

The Department of Natural Resources is responsible for the water appropriation permit system, groundwater monitoring and conservation principles, water recreation and invasive species concerns, flood mitigation management shore land and scenic river protection, water supply and planning, dam safety and water levels, stream flow monitoring and water mapping, and the Great Lakes Compact.<sup>27</sup> The Minnesota Department of Natural Resources permitting program is designed to protect 'public waters,' as well as to regulate appropriations of water resources for public or private use. It regulates the appropriation of water and operates a number of supporting programs to ensure that water supplies meet a variety of economic, social, and ecological purposes. The Department of Natural Resources adapts the concept of sustainability to water use: "Sustainable water use is the use of water to provide for the needs of society, now and in the future, without unacceptable social, economic, or environmental consequences."<sup>38</sup>

Individuals or firms that want to extract water directly from any groundwater or surface water source must obtain a permit from the Minnesota Department of Natural Resources. To obtain the permit, applicants must show that their proposed use will not damage existing ones. This has been an important policy for preventing the overuse of water, particularly groundwater. However, this does cause significant enforcement challenges for the Department of Natural Resources.<sup>17</sup> "The Minnesota Department of Natural Resources issues pumping permits for wells on a case-by-case basis. The agency does not deny permits based on the anticipated cumulative impact of each new well it approves, and the agency lacks authority to restrict development where groundwater is scarce."<sup>55</sup>

In issuing permits, the commissioner must follow an established order of water use priorities, with the top priority awarded to domestic water supplies, second to consumptive uses of less than 10,000 gallons per day, third to irrigation and food processing, fourth to power production, fifth to consumptive uses in excess of 10,000 gallons per day, and sixth to nonessential uses. All active water appropriation permit holders are required to monitor their water use, employing an approved flow monitoring device and to report their water use annually to the Department of Natural Resources. Water use permits are durational, limited to five years for most purposes but subject to "cancellation by the commissioner at any time if necessary to protect the public interests." Currently, about 7,000 water appropriation permits are in effect statewide; of these, about 900 are held by public water supply systems.<sup>28</sup>

The Department of Natural Resources Water Appropriation Permit Program is the centerpiece of Minnesota's efforts in pursuit of water sustainability. When a permit has been granted, the entity holding the permit is required to submit annual reports of water use. The program is developed around the idea that managers can adjust permit requirements based on observed trends in long-term monitoring data. Permits are permissive only and do not establish a right to appropriation nor a priority of appropriation. A permit may be restricted, suspended, amended, or canceled in accordance with applicable laws and rules for any cause for the protection of public interests, or in response to a violation of the provisions of the permit. Management need not wait for scientific certainty of individual permit impacts before making permit decisions or restricting permits to prevent negative consequences.<sup>54</sup>

### Economics and Water

The next issue that needed to be reviewed is potential water pricing options. Four different types of economic incentives can motivate consumers to cut back on the use of water and pollute less: charges or fees; quotas or rationing; subsidies for water-saving technologies, such as low-flow showers; and markets.<sup>17</sup>

In Minnesota, the most frequently used mechanisms to reduce water consumption have been water quotas, restrictions on certain uses during drought periods, and subsidies for water-saving technologies.<sup>17</sup> Eden Prairie, Minnesota, on the southwestern fringe of the Twin Cities, has a median family income that exceeds \$93,000. The city has year-round watering restrictions that include a prohibition on lawn watering between noon and five o'clock and an odd-day/even-day watering regimen. In 2007, the city issued more than 800 citations, with fees that started at \$25 for the first offense and climbed to \$300 for the fifth and each additional violation. City officials noticed that most repeat offenders lived in the wealthier neighborhoods. Even a \$300 fine, observes city manager Scott Neal "is well below the threshold of what it is worth to have a green lawn."<sup>24</sup>

### Taxes

Taxes are a type of fiscal incentive that could encourage efficient water use. One example of a tax is a phased-in, graduated tax on all surface water and groundwater use. Congress could give water users ample lead time to adjust their water practices before the tax kicks in.<sup>24</sup> In Singapore, a water-conservation tax introduced in 1991 charged an additional 5 percent for households that used more and an additional 10 percent for excessive commercial water use. The hike helped lower consumption in the commercial sector, which makes up about half the island's water use.<sup>5</sup> A tax system is both easy to

administer and to understand. Businesses could simply pay for any water use exceeding the designated threshold.<sup>57</sup>

Another option would be to, dollar by dollar, take taxes away from labor and income and instead place them on pollution, waste, carbon fuels, and resource exploitation, all of which are presently subsidized. A tax shift of this nature has to be steadily implemented over a long period of time, at least 15 years, so that business has a clear horizon over which to make strategic investments. Gradual changes can occur, current inventory can be used, but a clear long-term signal may allow for innovation. The end goal would be to remove all personal and business taxes on wages and income. However, gasoline, nuclear power, chlorine, motor oils, air traffic, pesticides, fertilizers, piped-in water, old-growth timber, wild fisheries, irrigation water from public lands, depletion of aquifers, sulfur, coal, silver, and all waste sent to a landfill or incinerator would all be heavily taxed commodities.<sup>25</sup>

### *Subsidies*

One example of a subsidy is that homeowners could receive monetary credit for installing low flow or waterless toilet fixtures. The latest generation of high-efficiency toilets use even less water and dispose of waste effectively; each toilet saves more than 11,000 gallons per year. A program could be instituted to offer rebates, redeemable at a local hardware store, for low-flow toilets, smart controllers, low-flow showerheads and pool covers. Another program could involve giveaways of low water-use fixtures, especially toilets.<sup>24</sup> One such program was done by the Clean Energy Resource Team in Minnesota. They ran a bulk-buy program for pre-rinse spray valves aerators. Upon the completion of the program in October, 2011, they estimate that the program will save 13.5 billion gallons of water and \$180,000 annually from 70 different participants.<sup>8</sup>

### *Markets*

In a market economy, buyers and sellers interact and trade, and out of this comes the prices of the items traded, which shift up or down through time as supply and demand factors change. For markets to perform well, property rights in water have to be clearly defined, reasonably complete, secure, and transferable. 'Clearly defined' means that there is no ambiguity about the nature of the right that is owned. By 'reasonably complete' is meant that water rights must not be so narrowly defined that the opportunities for exchange are unduly restricted. Property rights have to be secure if markets are to function well. They have to be defensible, at a reasonable cost, from would-be encroachers or appropriators. Markets work on the basis of price signals. If prices go up, it signals that demand is increasing relative to supply (or supply has decreased relative to demand); if prices go down, the opposite is true. For markets to function well, knowledge of prices must be widespread (i.e. no secret deals), and there must be competition among and between buyers and sellers. To have competition there must be a relatively large number of participants on both sides of the market. Another primary requirement is that markets have to be complete. Completeness has two components, completeness in the sense that all affected parties have the right to participate in the market and completeness in the sense that all impacts forthcoming from a water transfer are tradable on a market. The other method to effect the transfer is through transactions on a market for water rights. Market transactions occur because willing sellers meet willing buyers and trade something of value at a price agreed to by both participants.<sup>20</sup>

In recent years, interest has grown in moving away from administered transfers of water rights and toward greater reliance on water rights markets. A water market would function analogously to markets in other types of goods and services: willing sellers and buyers, individuals or groups, would be able to conclude private agreements to transfer given quantities of water at agreed-upon prices. As with any market, there would have to be rules and regulations covering these transactions. Ecosystem protection is a public good, and private markets are not particularly effective at representing the values of goods of this type.<sup>20</sup>

Free marketers and libertarians believe that the water industry would be better off if local governments got out of it altogether; they believe that the water business should be entirely privatized. They suggest that, in order to solve the water problems, the United States needs to move toward viewing water as a commodity (e.g. wheat, copper, or oil) and allow natural market forces to set its prices and more efficiently govern its allocation. Opponents to libertarianism argue that water should be viewed as a basic human right, with the implication that clean water should somehow be equally and freely available to all.<sup>32</sup> It is possible to encourage water conservation by using price signals and market forces

Market - based water transfers can take many forms. Transfers can include: sales, leases, forbearance agreements, dry-year options, and other conservation measures that save water. Each offers the prospect of a win-win result for both the buyer and the seller. The seller secures a price that he or she finds attractive and the buyer secures a water supply at a price that he or she finds attractive. The case for water marketing rests on the assumption that ownership of an item invests the owner with an incentive to take care of it.<sup>24</sup>

### *Water Pricing*

Nationwide, Americans pay an average of \$2.50 per 1000 gallons; that is \$.0025 per gallon or four gallons for a penny. Prices vary tremendously; typically they are higher in the Northeast and lower in the South and West. It costs the typical American family approximately \$20 per month for water. Residents are paying the costs of the water distribution system and, in some cases, the costs of a sewer system. Funds raised through water bills reimburse the municipal water department for providing this service to city residents. Private water companies recoup their costs plus a reasonable return on the company's investment - usually 8 to 10 percent. In other words, a water bill typically includes only the costs of delivering the water, including the extraction costs of drilling wells or of digging ditches and conveyance systems; the energy costs of pumping the water; the infrastructure costs of the distribution, storage, and water treatment systems; and the administrative costs of the water department or company. With very rare exceptions, water rates do not include a commodity charge for the water itself. The water is free.<sup>24</sup>

Minnesotans currently pay very little for water. Drinking water in Minneapolis costs less than four-tenths of a cent per gallon, on average. Water used for irrigation costs the permitting fee, cost of drilling a well, and cost of pumping water.<sup>22</sup> Currently (and not including the 2010 changes), 116 community water systems have some form of conservation pricing, 26 communities have a decreasing block price structure that discourages conservation, and the remainder of communities have a flat fee, uniform structure, or have not reported their structure.<sup>35</sup>

Among the general public, and especially among public administrators, the widespread belief is that the basic reason for having prices at all is to cover the costs of production. For those in charge of water and other public utilities this leads to a cost-based pricing rule: Set prices so that revenues cover costs. Revenues should not fall short of costs, because losses presumably have to be recovered in an alternative way; for example, from general tax revenue. Nor should revenues exceed costs, because this implies profits, which are thought to be inappropriate for public enterprises. This type of reasoning has historically led to what is called average-cost pricing. The total costs of delivering water are divided by the total quantity of water delivered, and unit water price set accordingly. The costs of a water system include the costs of conveyance systems and the costs of procuring the supplies of water, surface, or ground, that are delivered to consumers. As systems are expanded, the need to reach out farther for additional supplies often implies a rising marginal cost curve.<sup>20</sup>

### General

Six of the more common methods are a fixed charge per month or quarter, a constant rate per unit of water used, a decreasing block rate per unit of water used, an increasing block rate per unit of water use, a two-price method that includes a fixed charge plus a charge per unit of water used, and peak-load or seasonal pricing. The first goal of any rate structure is to generate sufficient revenues to maintain efficient and reliable utility operations, and the second is fairness in the allocation of utility service costs. Generally, it is possible to satisfy both of these goals in a rate structure that encourages water conservation or penalizes excessive water use.<sup>52</sup>

### Flat

The fixed charge per month is a price system that is found mostly in small towns and rural water systems. These are systems that have not invested in water meters and just want to cover basic operating costs. This method provides no incentive for the consumer to use less water. Consumers that use 150,000 L per month pay the same as those that use 5,000 L.

The constant rate (e.g. \$2 per 1,000 L used) provides the same incentive to conserve no matter how large the user. If consumers use 150,000 L they pay \$300, but if they use only 5,000L they pay \$10.<sup>17</sup>

### Increasing

In an increasing block rate pricing system, the incentive to conserve goes up as the consumer uses more water. For example, the rate could go from \$2 per 1000 L up to \$5 per 1,000 L once consumers use 100,000 L during the month. In this case, consumers of 150,000 L per month would pay \$450.<sup>17</sup>

### Decreasing

The decreasing block rate provides a smaller incentive for the more water that the user consumes. For example, the rate may drop from \$2 to \$1 per 1,000L once a consumer uses 100,000 L during the month. Consumers that use 150,000 L per month would pay \$250. This rate structure is frequently used to give industrial plants an incentive to locate in a particular city.<sup>17</sup>

### Seasonal

Seasonal or peak-load pricing can be used to increase the charge during periods of high water use (summer), when conservation is particularly important and the marginal value of water is high due to

high water demand. However, high prices may not be enough to curtail profligate water use because of leaks, large lawns, or undisciplined consumption.<sup>17</sup>

### *Two-Price*

In the two-price method, the fixed charge (for example: \$30) is to pay for those recurring costs that are not related to the quantity of water consumed. The second charge is a variable one based on the amount of water used and can be a constant, increasing or decreasing rate. It can also include a specific charge for water itself, in addition to delivery and treatment costs, based on the scarcity value of the water. In other words, when water is more scarce the consumer will be charged more.<sup>17</sup>

### **Eliminating Water Waste**

The last issue that needs to be reviewed is ways to eliminate water waste. It is expensive to transport and store water, to treat it up to potable standards, and then to dispose of the wastewater. The fact that there is 'left over' water following its primary use has important economic, legal, and social implications. Keeping track of water is complicated and often expensive.<sup>41</sup> Currently rural and urban infrastructure has not been maintained properly. Over 17 percent of clean drinking water produced in the United States leaks out of poorly maintained pipes.<sup>32</sup> Also, most wastewater that is generated along our coasts, which is cleaned to potable standards, is dumped into the oceans. This water could be recycled. Similarly, increasing conservation and efficiency would be more effective than attempting to find and clean new supplies of water.

### *Infrastructure*

The water infrastructure in the United States consists of approximately 54,000 drinking water systems, with more than 700,000 miles of pipes, and more than 17,000 wastewater treatment plants, with approximately 800,000 miles of pipes. The useful life of many of these plants and pipes is coming to an end. In 2003, the EPA estimated that over the next two decades the United States needs to spend \$276 billion to improve drinking water infrastructure and \$185 billion to upgrade and expand wastewater systems. The EPA concedes that this total of \$461 billion is a conservative estimate. In 2004, the American Society of Civil Engineers put the gap between needs and funding at more than \$0.5 trillion, A 2002 Congressional Budget Office estimate placed the range between \$500 billion and \$800 billion; the Water Infrastructure Network, a coalition of water industry, engineering, and environmental groups, pegs the future costs at \$1 trillion.<sup>24</sup>

There is a continuing need for the effective management of large water systems, public, and private, to adapt to the demands of growing urban and suburban populations.<sup>20</sup> A leaky toilet can waste as much as 200 gallons a day.<sup>24</sup> One leaking faucet can waste 3280 gallons of water every year. Thus, simple household and system repairs can save enormous amounts of water.<sup>7</sup> One of every six gallons of water pumped into water mains by United States utilities simply leaks away, back into the ground. Sixteen percent of the water disappears from pipes before it makes it to a home or business or factory. Every six days, United States water utilities lose an entire day's water.<sup>21</sup> Water pipes, ductile iron, steel or concrete, do not last for two hundred years. The underground water distribution infrastructure may be out of sight and out of mind for most people, but it is not being maintained appropriately. Hence, it is gradually crumbling.

New York has begun to fix this problem. During fiscal year 1990 – 19 alone, New York City put 26 people and \$1.5 million to work in a survey of more than 90 percent of the city's 57,000 miles of water mains. This resulted in repairs being done to 66 breaks and 671 leaks, and saved 49 million gallons per day. Since then the whole system has been rescanned every three years, and leaks have been decreased by 80 percent.<sup>25</sup>

Minnesota is also concerned about its infrastructure. The EPA estimates that Minnesota's drinking water infrastructure will need approximately \$6 billion for infrastructure upgrades over the next 20 years—not including accommodations for a growing population. The MPCA estimates that Minnesota's public wastewater infrastructure will need more than \$4.5 billion in improvements over the next 20 years. In addition, individual wastewater systems will need more than \$1.2 billion in improvements to protect the environment and public health.<sup>35</sup> Part of this money may be covered by a Clean Water Revolving Fund. This fund gives below market loans to communities in order to expand and upgrade wastewater treatment plants.<sup>9</sup> It is estimated that the the Clean Water Revolving fund will spend \$180 million in loans for projects in 2012.<sup>10</sup> However, this is not enough money to upgrade all of the necessary infrastructure in the state.

### *Re-Use*

Water reclamation is a treatment process that allows water reuse by another user. Direct reuse pipes water directly from the treatment center to the next user. Indirect reuse releases the water back into the environment before it is reused by the next user. In contrast, water recycling is the process of reusing water multiple times within one specific facility. Water quality requirements depend on whether the reuse is direct or indirect. For example, in indirect use, the water experiences natural purification.<sup>1</sup> As long as the water is treated to ensure quality adequate for the intended use, water reclamation and reuse can meet most water demands.

Reclaimed water is a viable way to address water shortages. It is estimated that reclaimed water use could fulfill 95% of industrial water use in Minnesota. Recycled wastewater for industrial use in Minnesota is currently required to meet regulatory limits based on the California Water Recycling Criteria, Title 22 California Code of Regulations (Title 22). The Minnesota Pollution Control Agency handles permitting recycled wastewater as part of the NPDES permit process. The cost to supply 1 million gallons of recycled wastewater per day would cost between \$1.35 to \$3.75 per 1000 gallons, depending on the water quality that is needed.<sup>39</sup>

The City of Tucson has been using recycled water for more than 20 years at over 900 sites. Recycled water is used for irrigation and landscaping at golf courses, parks, schools, and single family homes, as well as edible vegetable gardens, orchards, and toilet flushing. Using this reclaimed water, as it is called in Tucson, for irrigation saves groundwater for drinking. In 2009, 5.5 billion gallons of drinking water were saved, enough for 59,000 families for a year. Tucson's reclaimed water also costs less than potable water in all consumption blocks except the lowest.<sup>46</sup>

It may also be an option for larger businesses. For example, a northern German manufacturer of paper products for packaging almost eliminated its water use by completely recycling its base supply in a sophisticated process that successively sediments, floats, and filters the fiber and particulate loads from

the water. Only 1.5 pounds of water per pound of paper is still needed to offset evaporation and provide the water content of the paper itself. This residual water requirement is 600 times smaller than the European norm in 1900, or about 15-20 times below the recent German norm. Armco's Kansas City steel mill, now called the GST Steel Plant, uses its water at least 16 times over, purifying it in between uses in settling ponds. It now takes in only 3.6 million gallons a day even though it uses 58 million gallons a day.<sup>25</sup>

### *Conservation*

Water efficiency, as well as conservation policies, varies widely among cities. It is difficult to compare these programs because of monitoring and accounting practices are usually very inconsistent among different cities. Regardless, the strongest programs have similar characteristics in common. In addition to more stringent monitoring, they involve public education, widespread promotion, and permanent implementation

Encouraging water conservation in businesses and industry may yield better results than encouraging water conservation in residential use. Typically, energy and water saving devices are chosen by engineers at the firm's operating level, using a rule-of-thumb procedure called "simple payback" which calculates how many years of savings it takes to repay the investment in better efficiency and start earning clear profits.<sup>25</sup> For example, a building with "water-efficient designs and products averages 15 percent lower water use, 10 percent less energy consumption, and operating costs reduced by 12 percent." While the initial investment costs can be higher, the long term financials should convince major corporations to include water conservation in sustainability programs.

The following are several large corporations that have been able to implement water conservation techniques in their processes. Kraft Foods was able to decrease their water use by more than 20 percent, which equals three billion gallons in less than three years.<sup>5</sup> Chipmaker AMD modified a processing tool that allowed them to use fewer chemicals and less water to clean silicon wafers. They were able to decrease water use from 18 gallons per minute to less than six gallons per minute.<sup>19</sup> General Mills has constructed a new plant that includes an onsite wastewater treatment and recycling facility. The company expects to save \$400,000 in city wastewater treatment surcharges and \$440,000 in water-utility costs per year.<sup>18</sup> Interface Corporation, one of the world's largest producers of commercial floor coverings, reduced waste-water by 26% per unit of product from 1996 to 2001. This was accomplished through water conservation efforts, process enhancements such as re-using dyebath water, and eliminating processes such as printing. In the modular carpet business, water consumption per unit of product has been reduced by 68% during that time-period. The fabrics businesses reduced their consumption of water per unit of productivity by almost 35%. Interface's sustainability action plan generated cumulative savings from global waste elimination of over \$200 million from 1995 to 2002. Thus, conservation measures, especially when enacted comprehensively across the business, can save money and become a source of competitive advantage and thus create value.<sup>15</sup>

These corporations all made very large investments in water conservation. However, it should be stated that even small changes can have large effects. Some studies show that increasing the number of low flow toilets by one decreases household water demand by 10 percent.<sup>40</sup> This can be extrapolated to be

true in small businesses that work out of the home or small offices as well. It is not only large businesses that can make a dent in water use.

## Education

### Public Education

There is very little public education regarding the limits of water resources, since real concern and corresponding information arises generally only during crises such as droughts and floods.<sup>27</sup> Educating and engaging the public is critical when considering new alternatives to solve problems. In order for the policy to be easily and widely adopted, the public must have a positive impression about the policy. Education is important because water users are more likely to abide by policies when they understand the reasoning behind the policy and their contribution to the problem. One easy way to begin the publicity campaign is to use public service announcements to educate the public.<sup>24</sup>

When the government spearheads education and conversation, they are able to incorporate the corresponding public input into the policies that they are designing. Government involvement is not the only involvement that is necessary for public education campaigns. Credible non-governmental organizations can help by providing reliable evidence that supports government action. This is especially true because the public sometimes mistrusts the government and may be suspicious of information that is provided by them. In this case, non-governmental organizations can add credibility. In addition to environmental organizations, academic and selected research institutions could also be seen as trustworthy entities.

One particular education and community buy-in process that could be used is the Citizens Jury. The citizens' jury process is a method of public participation. A group of citizens are selected at random and are paid to attend informational hearings. Ultimately, they represent their community in making a particular policy recommendation. At least three Citizen Jury projects have been done in Minnesota, a 1995 project on hog farming and feedlots in Rice County, Minnesota; a 1996 project for the Minnesota Pollution Control Agency on ranking environmental risks and setting priorities; and a 1997 project on restructuring Minnesota's electric industry. They were conducted with public sponsorship. It is important to have sponsoring officials present who appreciate the process and will respect the recommendation, even if they go against the initial positions held by the sponsors.<sup>11</sup>

Another education example is seen in a program implemented by the Saint Paul on Mississippi Design Center. They are focusing on expanding water quality capacity in the area. With this focus, they wanted to find a way to let the public know about water resources. Thus, they developed water quality Method Cards, intended to guide best management practice in Saint Paul at the individual, block, neighborhood, and citywide levels. Cards were used because water quality manuals are cumbersome and difficult to understand.<sup>43</sup>

### Business Education

However, many businesses may not know how to begin the education and conservation process. First, companies must understand how conservation techniques can help their business. First, it is important to emphasize that using a full environmental costing system is beneficial. It may show environmental costs that can be eliminated by simple changes. It may also show processes or products that add no

value. Thus, understanding the environmental costs can lead to better pricing and creation of value of goods and services.<sup>18</sup>

Encouraging water conservation and use of recycled water in businesses is similar to discouraging waste and the inefficient use of resources. Water waste is an indicator of inefficiency within a business. Such inefficiencies can cause unnecessary costs. Many organizations already aim to increase their productivity and revenue by preventing things like unnecessary steps and product in production. One approach, ZERI (Zero Emissions Research Initiative), takes this one step further. With ZERI, all waste, including liquid water waste should be eliminated. Business should “do more with less until everything is done without producing waste.” Using the ZERI approach allows businesses to increase resource efficiency, generate innovation, increase incomes, create jobs, and reduce environmental impacts.<sup>15</sup>

Education must also outline other benefits to conserving water. Specifically, companies that successfully manage environmental risks lower operating costs. Conserving water may save money from reduced water use, reduced water disposal, possibly lower energy bills.<sup>52</sup> Process innovation and improvements may lower water usage and decrease costs of wastewater handling. Other benefits include being able to reduce the cost of capital, drive up stock market valuations, and keep insurance premiums reasonable. Through increased compliance, corresponding fees and fines may also be lowered, as well as diminishing legal costs and preventing the possibility of operation closures.<sup>18</sup> In Minnesota, examples of fees include Service Availability Charges from the Metropolitan Council Environmental Services. This charge is based on new connections and increased volumes of wastewater. One SAC unit equals 274 gallons of maximum potential daily wastewater flow volume. Effective January 1, 2012, the SAC unit fee rose to \$2,365, which is approximately \$8.63 per gallon.<sup>42</sup> Water access charges and strength of water charges can also be assessed. Companies are subject to this fee if they have spills of high strength wastewater.<sup>47</sup>

For example, 3M has a very specific conservation oriented business model. They believe that everything coming out of a plant is either a product, a by-product (which can be reused or sold), or waste. For them, reducing costs has, in Kathy Reed’s words (3M’s top environmental executive), “kept us competitive and allowed us to stay in industrial businesses.” For example, 3M decided not use solvents, and ended up limiting its exposure to new regulations, cut compliance costs, and reduced the risk of fines. Simultaneously, 3M showed its customers, local communities, and regulators that it was serious about reducing its ecological footprint.<sup>19</sup>

Businesses, especially smaller and midsize ones, need to be educated on how the above conservation efforts can help their profits, processes, and reputation. Smaller companies may not be able to hire consultants on their own, thus collaboration with the government to get this information would be useful. Another option is using the University of Minnesota’s Technical Assistance Program. It helps businesses develop solutions to maximize their resource use and reduce water use and costs to the environment. This advice is free and industry tailored. This assistance can come through personal site visits, full time internships, and/or an internal team facilitation meeting. In 2011, the Minnesota Technical Assistance Program helped save companies a total of \$3.1 million annually and saved 13.9 million gallons of water.<sup>47</sup> This is a very inexpensive and viable option for businesses. Also, there are numerous state agencies that have a stake in water quality and quantity regulation in Minnesota. This makes it difficult for businesses, as well as local governments, to know who is in charge of what.<sup>35</sup>

Additional water sustainability training and education can be incentivized and then later required at all large facilities that hold any type of water permit or license.<sup>35</sup> A voluntary type of education was done at Syvantis Technologies in Baxter, MN. Syvantis created an advisory group of realtors, natural resource professionals, energy experts, community funders, chamber of commerce members, builders, a development commission, educators, and conservation nonprofits for their expertise and support. This group was able to help Syvantis to learn about sustainability, as well as adapt processes and implement new sustainable technologies within their business. To help build this advisory group, companies could work with the Minnesota Master's Naturalist Program or consult the EE – Events (environmental education) list serve that is maintained by the Pollution Control Agency.<sup>29</sup> Media coverage is one way to communicate these options. Articles in magazines and local newspapers can also be helpful as a way to alert businesses to options.<sup>15</sup>

## Summary

Unlike other regions of the country and world that have experienced water shortages for years, Minnesota is uniquely poised to proactively manage its water resource in a way that both accommodates sensible growth and preserves natural resources to the lasting benefit of Minnesotans and Minnesota ecosystems.<sup>54</sup>

Minnesota's regulated riparian system is common within the United States. Their system of water regulation is highly diverse and is spread throughout the state's departments. Minnesota may benefit from a more holistic water management system in order to prevent water shortages in the future. A water management system could include an updated water permitting system within the Department of Natural Resources. It could include commercializing water or changing water pricing systems. Similarly, it would be better if clean water was not wasted through old and inefficient infrastructure. Lastly, no matter what the policy, education campaigns should be initiated in order to guarantee public support and enhance conservation efforts.

# Chapter Three: Discussion

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*Because water is a public resource, perhaps the government should provide it to citizens as a public service. But should the government allow citizens to use limitless quantities for trivial uses? Precisely because water is a public resource, the government has a stewardship obligation to manage it wisely.<sup>24</sup>*

## Introduction

### Purpose and Design of Study

The purpose of this study is to understand how the state government of Minnesota can work with high intensive water users to address potential future water shortages in Minnesota. The problem that Minnesota faces is that an increasing number of locations within Minnesota are experiencing shortages of clean water.

### Policy Criteria

To evaluate the proposed alternatives, a multi-criteria analysis is used, based on the following criteria. Each policy alternative will be assessed generally by the following criteria, which measure the expected performance of each option, each from a different perspective.

#### Effectiveness

The policy alternative that is chosen should successfully conserve the water in Minnesota's lakes, rivers, and aquifers. Conservation has the potential to both increase supply through water loss reduction and decrease demand through efficiency measures. The effectiveness criterion will also take into account the long-term viability of the policy alternative.

#### Cost-Benefit

The state government has shown a consistent commitment to implementing cost effective policies so this policy analysis will examine each policy alternative's costs and benefits. It is important to note that the lowest cost policy may not be the one implemented because this analysis will take into account the ratio of benefits to costs. Types of costs to be examined will include: transaction costs, operating and maintenance costs, initial capital outlays, costs to the government (i.e. lost tax revenue). The analysis will examine benefits to the public and to the environment.

#### Feasibility

Any regulatory or legislative action will need to be politically feasible. Included in this notion of political feasibility is also the public's attitude toward each policy option. Alternatives that would cause prices to increase or necessitate large behavioral changes will likely face some resistance from the legislative body. The analysis will also take into account the technological and geographic feasibility of each policy alternative including its ability for commercial scalability and ability to meet demand.

#### Equity

The analysis will assess the level and relative equity of burden placed on regions by each policy alternative. The burden of the alternative should be distributed fairly among stakeholders. Some alternatives, such as pricing incentives, will have a larger negative effect on those with limited incomes

or those who rely on water sources to make a living, such as farmers. Other alternatives will have a more uniform impact.

### **Environmental Health & Safety**

Each policy option will have an effect on the environment, however attenuated those effects might seem from the policy itself. It is therefore important to consider potential environmental effects and public safety risks a policy may engender. Although there are bound to be uncertainties in any analysis, a thorough accounting for the environmental implications of a policy proposal is critical.

### **Longevity**

Longevity will assess the length of time the alternative is thought to be relevant and effective. Pricing mechanisms and conservation incentives can be either temporary or permanent, but implementing a water recycling system can only be a long term investment. The effects of all the alternatives have the potential to be long-lasting, depending on the actual program that would be implemented.

### **Flexibility**

Flexibility evaluates the ease with which the alternative can be altered to reflect changes in the supply and demand of water in Minnesota over time. Pricing and conservation are the most flexible as incentives can be ramped up or down fairly quickly, whereas water recycling infrastructure is much more difficult to change without planning and have a significant upfront capital cost.

### **Trade-Offs of Alternatives**

Each of the previously discussed policy alternatives have broader trade-offs that manifest in a wide variety of ways across sectors. The issue of water is a practice in finite resources – limited natural resources, physical space, political will and capital, public trust, funds, and knowledge. The ‘best’ alternative will not be the perfect solution; rather, it will be the optimal choice upon consideration of the values that go into balancing the trade-offs inherent in the policy design. The following is a discussion of the trade-offs present in the alternatives in this report.

### **Trade-Offs: Government Options**

Current water law has been put in place without much effort to make sure new additions to the law do not overlap or create inconsistencies with existing laws. Similarly, no single method or activity will solve the state's challenges. The literature has been consistent in that water policy should take a holistic approach that considers the physical, social, and economic conditions within watershed, aquifer, and river basin contexts.<sup>17</sup> Managers need to continue some practices, improve others, develop complementary new approaches, and continually set and reset priorities as they gain new knowledge.<sup>54</sup> State responses to higher water demand may require mixed solutions such as infrastructure upgrades, changes in behavior, and additional regulation.<sup>37</sup>

Often governments recommend voluntary water use standards for industries to follow, but these recommendations are not very effective. However, it is a fine line between enacting laws that prevent unacceptable environmental impacts while still encouraging companies to innovate and be profitable. Unfortunately, when companies are forced to invest in technologies solely because of government regulations, they may not realize the full benefits that could be associated with such an investment project, because their goal is to meet the regulations in the least expensive way possible.<sup>18</sup> In this way,

the government cannot fully protect the environment because it does not eliminate the sources of problems. Regulations do not address all of the processes of ecosystems or interrelationships between the environment and human uses. Although best management practices are required by many regulatory agencies, they do not prevent all environmental impacts. They are “better than nothing” but not the best. Thus, while it is crucial that all corporations be in compliance with regulations, compliance alone cannot lead society to sustainability. Businesses must be convinced in other ways to act in a sustainable manner.<sup>15</sup>

In the future, literature has indicated that “the ideal water allocation mechanism should accomplish four goals: Clarity: Minimize uncertainty and the resulting conflicts between users; Economic Efficiency: Maximize the total net benefits of water use; Environmental protection: Balance human and ecosystem use by accounting for the benefits provided by in-stream flows; and Distributional equity: Distribute the benefits of water use in an equitable manner.”<sup>1</sup> Including all of these goals in the creating a policy may allow for multiple purposes to be addressed and for the greatest number of benefits to be realized.

### Trade-Offs: Permitting

There are some tradeoffs that need to be considered regarding permitting adjustments. One possible approach is for the government to target wasteful practices by simply changing permitting laws by prohibiting current water users from using so much. A second type of conservation involves mandatory temporary restrictions on water use. These restrictions, usually adopted during a drought emergency, typically limited water use to certain hours of the day or days of the week, or prohibit certain activities, such as washing cars, watering lawns, or filling pools. Long-term regulatory programs often mandate low-flow fixtures in new construction or prohibit ornamental fountains or lawns over a certain size or in particular locations.<sup>24</sup>

While changing the overarching water law by directly addresses the issue of reduced supply by aligning permits with actual supply, it may be met with resistance, increasing the need for enforcement mechanisms. Heavy-handed government mandates would also generate bitter political controversy and endless litigation. A benefit of this alternative is that it has no direct monetary costs, although in order to satisfy a new allocation regime, investment in other alternatives would likely be necessary. Command and control regulation may ensure that the specified goal is met but tends to be more expensive and less flexible than market mechanisms. In this sense, the desire for predictability and definite results is somewhat opposed to minimizing expenses and spurring innovation.

### Trade-Offs: Taxes

There are tradeoffs to changing both the tax and subsidy structures in the state. Current income tax structures are common throughout the United States. While changing the taxes to resource taxes now may put Minnesota more in line with future structures in Europe, changing now would be a radical option that has not yet been adequately tested. Shifting taxes toward resources incentivizes lower resource use. This may encourage more research and innovation into resource efficiency and productivity. The result of this type of tax change is that individuals and businesses could theoretically “avoid” taxes by changing behavior, designs, processes, and purchases. For example, Denmark’s landfill taxes increased the reuse of construction debris from 12 to 82 percent in less than a decade. Inquiries and small trial shifts are already underway in Sweden, Britain, Germany, the Netherlands, and Norway.

As Europe and other countries move toward tax shifting, it may force the United States to follow, for the very simple reason that it may lower our competitor's labor costs while spurring their innovation. It may also help to ensure that the economic vitality stimulated will moderate, not worsen, the burden on natural capital.<sup>25</sup> Revenue – neutral shifting of taxes from things we do want to things we do not want may send strong behavioral-change signals to important corporate stakeholders.<sup>57</sup>

However, introducing new taxes may not only encourage conservation but also generate funds to underwrite expensive infrastructure repairs, conservation programs, and environmental restoration. However, there is no guarantee that the environment would benefit and that water use would decrease. Some businesses may be more willing to pay a fine or tax instead of reducing their water use.

### Trade-Offs: Subsidies

Fiscal incentives such as subsidies would encourage the development and use of reduced water technologies. Presently, the benefits from a homeowner taking such a step are also an advantage for the broader community as a whole; that homeowner uses less water and generates less wastewater to be processed. As great as these programs would be in the community, they are not necessarily the most economically efficient; this option is very capital-intensive. There is both a high cost and a low benefit due to the fact that most of the significant water use does not come from residential use, but rather from industrial use of groundwater. Any new subsidy program should focus on industry, rather than residential.

Currently there are many 'perverse subsidies' available that subsidize environmentally destructive practices. The goal of subsidies is to help people, industries, and products that need to overcome substantial cost, pricing, and market disadvantages. Perverse subsidies actually function as a disinvestment and leave the environment worse than if the subsidy was not in use. "They inflate the costs of government, add to deficits that in turn raise taxes, and drive out scarce capital from markets where it is needed. They confuse investors by sending distorting signals to markets; they suppress innovation and technological change; they provide incentives for inefficiency and consumption rather than productivity and conservation."<sup>25</sup> One example of a perverse subsidy is water for irrigation. This water is sometimes subsidized and provided at a price that is lower than that of industrial users. Pricing water at the true value of it would not only encourage more efficient water use but also mean higher food prices, which would be a benefit for the long-term sustainability of agriculture.<sup>1</sup> Fifteen direct subsidies to virgin resource extraction and waste disposal industries will account for another \$13 billion in the next five years.<sup>25</sup> To make up for this, subsidies could be shifted from industries such as fossil fuels to clean- technology and water efficient industries.<sup>57</sup>

### Trade-Offs: Markets

If water markets are to flourish, there must be a system of quantified water rights that are transferable. Water markets can develop only if current water users have known and fixed rights that they can sell or lease. Without a property right that is quantified and transferable, it is unlikely that there will be a voluntary reallocation of water use. Ensuring that markets fulfill their promise requires us to remember their true purpose. They allocate scarce resources efficiently over the short term. Economic efficiency is an admirable means only so long as one remembers that it is not an end in itself. Markets are meant to be efficient, not sufficient; aggressively competitive, not fair. Markets were never meant to achieve

community or integrity, beauty or justice, sustainability or sacredness.<sup>25</sup> Markets cannot be the only aspect of the solution.

### Trade-Offs: Water Pricing

What has not been attempted in the United States is to encourage water conservation through price signals that create financial incentives to conserve. For water to be conserved, the price of water must rise. Raising the price of water would encourage all users - homeowners, farmers, businesses, and industrial users - to examine carefully how they use water, for what purposes, and in what quantity. Economists agree that rate increases would encourage water users to eliminate marginal economic uses and use the water for more productive purposes. An increase in rates might stimulate new water-saving technologies and efforts to harvest water. Water must be treated as a valuable, exhaustible public resource. Water is a basic commodity for which there is no substitute, regardless of price.<sup>24</sup> Rate structures work best as a conservation tool when coupled with a sustained customer education program.<sup>52</sup>

Currently the cost of water only takes into account extraction and infrastructure costs. The true cost of water is much higher when one takes scarcity into account. Water should be appropriately priced in Minnesota in order to maximize efficiency while minimizing externalities. The price paid for the water would reflect the cost of conserving water and the scarcity value of the water. It may take time to develop the information and enforcement mechanisms needed to operate such a market.<sup>17</sup>

There are trade-offs involved in water pricing that reflect the equity between stakeholders. Pricing water appropriately would stimulate all users to reexamine their uses and decide for themselves, on the basis of their own pocketbooks, which uses to curtail and which to continue.<sup>24</sup> Poor residents may have a weakened ability to purchase water for their basic needs, making it necessary to expand government welfare assistance to include water use. Wealthier users may be less impacted by increased prices and continue extravagant use, but the fees raised may, for this purpose, cover more of the real costs of intensive water use and may have an overall effect of decreased waste.

Demand elasticity measures how demand changes in accordance to a 1% change in price. Several studies have found that residential water demand in the United States has an elasticity of about -0.4. This elasticity will tend to be higher at higher prices and over longer time periods. Longer time periods encourage more permanent behavior change techniques as well as encourage the innovation and use of more water efficient technologies such as drip irrigation and low flow toilets.<sup>40</sup> Elasticity is also increased by the types of water bills that specifically list marginal prices, so that customers understand the price they are paying for their water uses.<sup>1</sup>

The studies also found that price elasticity varied between households based on household income. Households with lower incomes had a higher price elasticity than households with higher incomes. For example, a low income household would have a demand elasticity of -0.53 but a wealthy household would have a demand elasticity of -0.11. This discrepancy highlights the importance of careful pricing so as not to overburden low income households.<sup>40</sup> Because of this, a two priced or increasing block method would be best. This would allow for the inelasticity of residential use and keep those prices low but would also account for the more elastic demand of commercial water users.

It is important to note that consumer prices around the world reflect only physical supply costs and not the scarcity-based value of water. Another problem with current water pricing is the practice of the water utilities and governments of setting prices to cover historic costs and not future replacement costs, which will always be higher per unit than the historic ones.<sup>41</sup>

Major industrial operations have basically ignored the cost of water when locating manufacturing facilities and focused instead of finding cheaper labor or cheaper energy sources. As water prices rise, industries that use abundant water may begin to be located in areas of more plentiful water. Another trend is that water may be used much more efficiently by the factory - to conserve water and reduce usage, to recycle wastewaters for reuse in manufacturing processes, and even to prevent wastewater discharges altogether in what is called zero liquid discharge. More efficient industrial water usage is growing rapidly around the world, because it makes environmental and economic sense, and it may accelerate even further as water prices rise.<sup>32</sup> Similarly, if the environmental community embraces water transfers/pricing, this may lessen the pressure to build new dams, divert additional surface water, and drill more wells.<sup>24</sup>

The price that most urban users pay for water does not match the true cost of water to the environment, society, or even the marginal cost to distributors.<sup>56</sup> Local water distributors can play a role in changing water use by increasing or varying usage rates to align with availability. Rather than uniform rates or decreasing block rates (lower the price of water per gallon when purchased in bulk), water rate structures that utilize increasing block rates (unit price is higher when more water is used) or seasonal rates (higher in the summer, during low-supply drought and high-demand growing season) offer price incentives that correlate more closely with the real cost of water. Such pricing strategies have been effectively used to improve efficiency and discourage wasteful water use in certain urban areas. Current charges largely reflect immediate costs of building infrastructure but not the shortage in supply, cost of recovery from diminishing reservoirs, or demand elasticity.<sup>6</sup> Water prices are so low that consumers may not have realistic information to make informed decisions concerning their water use. More realistic pricing alternatives that internalize these additional costs may in turn reduce unnecessary use of water resources.

One possibility is to institute declining block pricing - a higher price for the first quantity of water, and then a lower price at far higher consumption levels. While this solves efficiency problems in the short run, it has the unfortunate implication that lower prices lead to higher consumption levels, which runs against notions of the desirability of water conservation.<sup>20</sup>

The increasing block charge generally provides the best incentive to reduce water use and tends to be employed in cities with limited water supplies and growing water demands. Because the demand for a number of water uses, such as drinking and cooking, tends to be quite steep (inelastic), large price increases will likely bring about only small changes in the quantities used for these purposes, particularly for those with higher incomes. An increasing block rate structure is not suitable for an unmetered area or where there is strong customer resistance. Water meters enable a city to insist that residents be responsible in their water use or pay financial consequences. Not surprisingly, residents in cities without meters use considerably more water than do residents in cities with meters. Data collection, including a

mandate to install meters, is an obvious first step. To free up water for valuable new uses, states must first recognize and quantify existing rights in water.<sup>24</sup>

Conservation-oriented water rate structures by themselves do not constitute an effective water conservation program. Rate structures work best as a conservation tool when coupled with a sustained customer education program. Customer education is important to establish and maintain the link between customer behaviors and their water bill. Utility customers require practical information about water-conserving practices and technologies. Participation in other water conservation programs, such as plumbing-fixture retrofit and replacement programs, can also be enhanced by rate incentives and customer education. Finally, public acceptance of rate structure changes is often enhanced if customers understand the need for and benefits of water conservation.<sup>52</sup>

### Trade-Offs: Infrastructure Options

This is one of the great challenges of the United States water utility industry: to convince ratepayers and the general public that they need to be paying more for water so that the government has the money to sustainably manage water infrastructure into the future. People in the United States still seem to be willing to tolerate massive losses of clean drinking water as a result of a dilapidated infrastructure and decaying pipes. The USEPA says that 17 percent of the clean drinking water produced in the United States essentially vanishes out of leaky pipes. This is some of the best drinking water in the world; the same water could save millions of lives in poor countries, and yet in Boston one gallon in three seeps away unused. In London, as much as one gallon in two drains way out of those pipes under the city, some of which are still made of wood.<sup>32</sup>

Combined storm and sewer water is treated to potable standards when only 10 percent of the water delivered to homes and businesses is used for drinking and cooking. American cities and towns annually spend more than \$50 billion to treat water to drinking water standards. A substantial amount of this money pays for energy to collect, treat, and distribute the water. It makes less sense to simply to rebuild the existing wastewater infrastructure than to incorporate an additional set of pipes for storm or non-potable water. Most wastewater generated along the coasts ends up in the ocean. Wastewater discharged into the ocean will not be available for reuse until the hydrologic cycle brings it back around again - a process that may takes scores or hundreds of years. Every time someone in eastern Massachusetts flushes a toilet, as much as six gallons end up in the ocean. Municipalities spend billions of dollars annually to treat the sewage that is produced. The managers of municipal water facilities prepare water to drinking water quality, send it to homes, where people urinate and defecate in it, and send it back to begin the process all over again. Treating all water to potable standards makes no sense given that only a small fraction of it, roughly 10 percent, is used for drinking and cooking. It is an enormous waste of money and energy.<sup>24</sup> Water reclamation would be one possible infrastructure solution for this problem.

There are some tradeoffs that need to be considered regarding water re-use. There are significant upfront costs to build the necessary infrastructure. Without economic incentives, it may be difficult to get the necessary infrastructure built. The cost of a reclaimed water system is substantial because a completely separate infrastructure system must be installed so that there is no chance of contamination between potable and non-potable water.<sup>24</sup> This option may initially be more expensive than imported or

groundwater use, but this option is more cost-effective in the long term when all costs, including environmental benefits and avoided harm, are included. There are also institutional barriers and varying agency priorities that can make implementation difficult, along with the need for early public outreach in the planning process to address citizen concerns and keep the public involved.<sup>48</sup>

As a result of its large and bulky investments for infrastructure there are economies-of-scales for water projects. This makes the tradeoff between short-term and long-term investment decisions more complex, typically leading to 50- to 100-year horizon investments. Retrofitting current infrastructure and investing in technological solutions requires significant upfront costs. It is often difficult to balance these immediate costs with the ecological and financial costs of the future. Similarly, waste water systems are only cost competitive at use of at least 1 million gallons per day or higher.<sup>39</sup>

Another issue is that industries and wastewater plants are not always close to each other. Depending on where the pipelines are built, some businesses might have greater access to the recycled water than others. For instance, recycled water has valuable uses for agriculture, but if the pipelines are not built to extend to rural lands or are not as dense in rural areas, farmers could have more limited access than the more concentrated urban populations. Similarly, in order for recycled water to have industrial use, storage would need to be built for peak hour requirements. Despite the use in Tucson, capital intensive reclamation facilities may not provide an economic return in smaller communities. Also, all municipalities may need partners in order to be successful. Industries may need to commit to municipalities to use recycled water in order to fulfill their water needs. This difficulty is highlighted by the fact that there is currently only one industrial use for recycled wastewater in Minnesota. The Mankato Energy Center uses 6.2 million gallons of waste water per day for its cooling water.<sup>39</sup>

Recycled wastewater should replace water that is used and not returned to its original source. This applies to all uses of ground water.<sup>39</sup> Investing in a water reuse system has a variety of benefits including locally controlled water supply, decreased diversion from sensitive ecosystems, decreased wastewater discharge into sensitive ecosystems, reduced water pollution, and reduced fertilizer use as recycled water is often nutrient rich.<sup>48</sup> At large enough volumes, the recycling system immediately and directly addresses the problem of reduced supply. It is also a long term solution that can be utilized even if supply in the river itself continues to decrease and especially as development causes demand to increase.

Implementing a water recycling system could be beneficial to many stakeholders, including farmers who could use the recycled water for irrigation, urban populations who could use the water for landscaping and plumbing, ecosystems that would face less depletion and strain, and the government regulators who would have more flexibility in distributing allocations. Although the recycled water may be less expensive than fully treated potable water, depending on how the initial infrastructure costs are distributed, the brunt of the expense could be passed on to consumers if not paid for by a government grant. If this is the case, the benefits received by industry and residents from having a greater supply of water may be offset by high initial costs.

It grows as the population grows, and it has confirmed uses that would save potable water for human consumption. Its multiple limitations include high costs for a dual system of pipes and valves, consumer

acceptance problems, and implications involving endocrine-disrupting compounds. Still, it is a terrific, renewable source that expands the supply. As things stand now, sewage is treated to nearly potable water quality and then discarded.<sup>24</sup> It is very unusual for reclaimed wastewater to be used as drinking water. However, planned reclaimed water consumption may be cleaner than the unplanned and indirect reuse of downstream river water that contains a treated wastewater.<sup>1</sup> Throughout the United States, there are more than one thousand projects that use reclaimed water. However, this usage is one percent of the total water usage in the United States. In contrast, 8 percent of Israel's water use was from reclaimed water in 1998.<sup>25</sup> Thus, the United States has lots of room to grow this water option.

### Trade Offs: Conservation

The increasing efforts in water conservation are spurred by a number of factors: growing competition or limited supplies, increasing costs and difficulties in developing new supplies, optimization of existing facilities, delay or reduction of capital investments in capacity expansion, and adequate water supplies to preserve environmental integrity.<sup>52</sup> Water conservation and efficiency currently is far more cost-effective than attempting to find or clean new supplies of water.<sup>2</sup> Water efficiency costs between \$450 and \$1600 for every million gallons it saves. In comparison, desalination costs about \$15,000 for the same million gallons. An Alliance study found that a \$10 billion investment in efficiency projects would create 150,000 to 222,000 jobs and save between six and a half trillion and ten trillion gallons of water.<sup>5</sup>

Policies set at the municipal utility level provide a high level of flexibility, which is particularly important if they are intended for temporary solutions. However, the flexibility is often a tradeoff with coordination efficiency. Also, attempted conservation programs should be widespread among all stakeholders. Most stakeholders may only accept responsibility if it is a collective effort among everyone. Finally, conservation programs need to be pro-active and permanent.

Conservation efforts should not just be implemented in drought conditions, but should be used to mitigate long-term water demand problems. Encouraging conservation techniques is similar to implementing voluntary mandates. There is no enforcement mechanism or way to track who participates in the program. Conservation programs can substantially reduce water consumption. However, because individuals rarely experience water shortages, there is generally no incentive to self-regulate water use.

The prospective statewide conservation programs are likely to have high long-term compliance because residential, agricultural, and industrial users will likely adopt new water practices, possibly more strict than mandated because of the anticipation of future changes. However, as population continues to grow, the effectiveness of conservation programs may diminish. It is likely that water demand will continue to grow as population growth outpaces water conservation savings. Conservation alone will likely not be able to meet future water demands. Reducing water use and encouraging conservation as well as the adoption of new technologies will be a long term goal and cannot be accomplished during the short period of time. If the program is to be successful, concerns of citizens must be solicited and addressed. If these are not incorporated early in the process, it is quite possible that the public mandate given to the program may be withdrawn.

Consensus groups, focus group discussions and public comment periods are some examples of encouraging public participation and may be important for the long term success of any water conservation program. Conservation in one area can benefit downstream users, so increased state participation may improve program equity and reinforce the water savings. Areas that lack proper infrastructure, such as some Native American communities, may not directly benefit from conservation programs. Learning by doing is an important educational component that may make more people conscious about their water use.<sup>24</sup>

Conservation programs typically involve up-front costs, including revenue losses. The full benefits of conservation are realized only after all savings have materialized. However, reduced water sales because of conservation often develop slowly in small increments that can be accommodated in periodic rate adjustments. Over the long-term, conservation can decrease a utility's need for new capital facilities for supply acquisition, treatment, storage, pumping, and distribution. It may also reduce the cost of operating those facilities. Water conservation can affect wastewater collection and treatment systems. Water efficiency can relieve an overloaded sewage-treatment plant without costly upgrades or expansions. The reduced flow also allows the plants to function better overall.<sup>25</sup> Reduced hydraulic loadings can improve treatment performance in terms of effluent quality and reduced operating costs. Reducing wastewater flows through conservation can result in cost savings by deferring the need to enlarge wastewater treatment facilities.

There are two primary benefits to reductions of wastewater volumes caused by decreases in indoor water use from more efficient plumbing fixtures and appliances. Most notably, benefits are in the form of reductions in operating and maintenance costs such as energy and chemicals. Also, a benefit arises from the use of less heated water through water efficient showerheads and clothes washers; this directly translates into energy savings for energy utilities. Many energy utilities co-fund programs with local water utilities to capture these mutual benefits. In areas experiencing population growth, conservation can provide additional capacity to accommodate growth, resulting in a larger customer base over which to spread future capital costs. Water rates may be lower with conservation than without.<sup>52</sup>

### Trade-Offs: Education

Engaging the public is a critical component for long term success, but the trade-off is if mishandled it can result in a loss of public trust and support. If people do not have a chance to discuss a new policy, it may not be supported. Feedback from the public with no visible changes or incorporation of ideas may result in confusion, cynicism and disbelief. Planned and ongoing meetings with the public and other stakeholders are crucial to the success of any policy. Government and businesses should feel comfortable sharing hard data, openly discussing successes and failures, and giving candid feedback.<sup>15</sup>

Another trade-off can be in the selection and participatory process, where group accessibility and availability may cause segments of the community who have an interest to be overlooked. Alternately, public participation could result in the over-representation of the interested few who do not necessarily hold the same views as the majority, but have the interest or time to commit to participation.

Partnering with organizations can also have drawbacks, where conflicting goals (between the federal/state government and the organization or among the organizations) could harm future relations.

Further, partnering with the ‘wrong’ group could have negative consequences for both parties. But if successful, a public education and engagement initiative may help guarantee public support for long term adoption of better and stable water conservation practices.

As demand for water increases, the public may scrutinize water use by businesses. The companies that use water indiscriminately have already begun to face public, political, and legal attacks.<sup>19</sup> Companies may need to begin to conserve water, reduce usage, and recycle wastewaters for reuse in manufacturing processes. This efficient use of industrial water may become more important as water prices rise.<sup>32</sup> By being at least in compliance with the law, businesses may also avoid the costs of lost goodwill because public perception of the company and its reputation may be good.<sup>19</sup> Because environmental issues are important to many stakeholders, conservation improvements can strengthen customer satisfaction, loyalty, and trust. Numerous studies have shown that consumers have a more favorable image of corporates that support causes that the consumers care about, and that many consumers report that they would switch brands based on social reputation.<sup>18</sup> On the revenue side, depending on the business environmental stewardship may allow for a product to be sold at a premium price.<sup>19</sup> Revenues can also be increased through increased sales due to improved corporate reputation. The goal is to simultaneously achieve excellence in social and environmental and financial performance.<sup>18</sup>

## Limitations

This study has some major limitations. First and foremost, there was no primary research done within this study. A more complete study would include using a sample of Minnesota businesses and legislators to understand how the two groups can work together to find a mutually beneficial water supply solution. Specifically people from agriculture, energy, and other water-intensive industries should be examined. The examination should be conducted and data collected through in-depth interviews as well as a multiple choice survey. Data could also be collected through a ranking system of potential policy options by the interviewees where the interviewee will rank each option based on the criterion of effectiveness, industry feasibility, and cost efficiency. The interviews and corresponding survey and ranking data could be coded and analyzed through qualitative analysis software. An analysis should focus on themes related to the research questions that are listed above. The primary goal of this study would be to gather and analyze the data in order to generate the most politically and business feasible options for water conservation policy in Minnesota and the broad setting of the research should be conducted in the Minneapolis – Saint Paul Metropolitan Area within the state of Minnesota.

## Conclusions and Policy Recommendations

Section 103G.265 of the Minnesota Statutes says: *“The commissioner shall develop and manage water resources to assure an adequate supply to meet long-range seasonal requirements for domestic, municipal, industrial, agricultural, fish and wildlife, recreational, power, navigation, and quality control purposes from waters of the state.”*

Maintaining the status quo is absolutely unacceptable. Making no policy changes may further minimize Minnesota’s water supply and could lead to future water shortages. However, no action is the most economical and the most politically feasible option. It is often easier to do nothing than to make progress on statewide problems. However, Minnesota has successfully been able to enact legislation in

the past. Legislation, enacted after a drought in 1986-89, phased out once-through air conditioning systems that pumped ground water through cooling coils. This resulted in a savings of 6.6 billion gallons a year of groundwater.<sup>22</sup>

Therefore, it is recommended that the state take up the various alternatives that have been listed in a combination. While enacting one alternative may be helpful to reduce the goal of minimizing water scarcity in Minnesota, it is highly unlikely that implementing only one alternative will be enough to prevent future economic and ecological damage.

All of the alternatives will benefit the environment in some way; however they have different pros and cons based on the criteria. For example, fixing current water infrastructure or adding new infrastructure to allow for water recycling would be one of the most highly effective alternatives in terms of reducing industrial water use. However, both of these alternatives are very expensive. Conversely, the most low cost alternative and one of the more politically feasible alternatives is business and industry education (e.g. free consultation services about conservation). Unfortunately, it is unlikely that conservation education will be an effective form of water use reduction by itself. The alternatives of implementing a new water pricing system or implementing a water market have the advantages of being both a long term solution and very flexible, since the prices will change to reflect the supply at the given time.

Ultimately, it is for the state legislature of Minnesota to decide in which alternatives to invest. However, the recommendation of this paper is to invest in updating water infrastructure, changing water price structures to an increasing block rate, and entering into a public education campaign.

In terms of changing the water price, current pricing is low and only takes into account extraction and infrastructure costs. Water must be priced in order to take scarcity into account. Price signals must encourage all users, but especially industrial water users, to conserve water through financial incentives. The most effective water pricing alternative to encourage conservation is a 'two-price' or 'increasing block' system. This way, prices can start low for basic needs and residential use, but increase for industrial water use. Thus, as users use more water, the price goes up. This gives the users the best incentive to limit water use.

The increased revenue that state and municipal water providers receive from the new pricing structure should go to updating the current pipes and water infrastructure. One out of every six gallons that is pumped into water mains by utilities leaks away into the ground before it reaches the consumer. Infrastructure is not being maintained at the appropriate rate; it is often out of sight and out of mind. The Clean Water Revolving Funds have begun to help communities with these expensive upgrades, but more money is needed for a full overhaul of pipe and infrastructure repairs.

Because water is not often on the public's mind except during droughts or floods, the public must also be educated about why to conserve. Customer education will establish the link between their behavior and their water bill. Similarly, in order for any public policy to be supported and widely adopted, the public must have a positive impression about the policy. Similarly, water conservation is not a priority for all businesses and intensive water use industries. Education campaigns that educate how conservation will help businesses as well as education on how to begin the water conservation process within a business are necessary.

These recommendations are not the only integrated water management options that the state of Minnesota can use to make progress in preventing future water shortages. These recommendations represent options that are not too expensive or too politically difficult to enact, while still enabling a constant clean water supply within the state. They are alternatives that should have broad support by both the public and the legislature. Hopefully, the political culture in the future may allow for more alternatives to be enacted, such as the expansion of water reclamation or changes in the tax structure.

# Chapter Four: Appendices

## Appendix A: Stakeholder Analysis

Table adapted from Varvasovszky and Brugha (Varvasovszky & Brugha, 2000)

| <i>Stakeholder</i>              | <i>Involvement in the issue</i>                                                                                                         | <i>Interest in the issue</i> | <i>Power/Influence</i> | <i>Position/Attitude</i>                                                                                       |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|------------------------------|------------------------|----------------------------------------------------------------------------------------------------------------|
| Energy Lobby                    | Produces various forms of energy including electricity and ethanol. Each of these production processes requires large amounts of water. | High                         | High                   | Favorable toward policies that reduce scarcity without increasing water costs                                  |
| State Government/State Agencies | Coordinates state water policy, incentivizes/mandates water technologies                                                                | High                         | High                   | Favorable toward policies that enable all of the state's needs to be met without a significant economic strain |
| Farm Lobby                      | Promotes the support of local farmers                                                                                                   | High                         | High                   | Favorable toward policies that reduce scarcity without increasing water costs                                  |
| Other Business                  | Has to use water for various manufacturing and industrial processes                                                                     | Medium                       | Medium                 | Favorable toward policies that reduce scarcity without increasing water costs                                  |
| General Public                  | Pays for water, has to deal with the effects of ecosystem change                                                                        | Medium                       | Low                    | Positions are highly varied but common concerns include: rate increases and availability                       |

|                     |                                                                                                                             |        |        |                                                                                       |
|---------------------|-----------------------------------------------------------------------------------------------------------------------------|--------|--------|---------------------------------------------------------------------------------------|
| The Environment     | Copes with the action of humankind                                                                                          | High   | Low    | Presumably in favor of water conservation in order to limit environmental degradation |
| Environmental Lobby | Wants to mitigate ecosystem changes through conservation and water efficient technologies, and ensure environmental justice | High   | Medium | Supportive of water conservation                                                      |
| Research Institutes | Receives government funding for water research                                                                              | Medium | Low    | Varied. Supportive of policies that further their individual research interests       |

## Appendix B: Policy Analysis Criteria

| Alternatives                            | Effectiveness                                                                        | Cost-Benefit                                                                                                | Feasibility                                                                                                                                    | Equity                                                                                | Environmental Health & Safety                                                                                                           | Longevity                                                                                           | Flexibility                                              |
|-----------------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| Status Quo                              | The status quo will not be effective at minimizing Minnesota's future water scarcity | The status quo would be cost-beneficial                                                                     | The status would not be completely politically feasible because there are many stakeholders that are worried about water scarcity in Minnesota | The status quo is not equitable between all stakeholders                              | The status quo will not protect either environmental or human health and safety                                                         | The status quo is not a long term solution.                                                         | The status quo is very flexible                          |
| Infrastructure (Supply Side Management) | It directly addresses the supply issue and allows for demand to increase             | Upfront costs are expensive but it will be cost effective in the long run                                   | If the upfront costs can be managed, technical considerations are minimal                                                                      | There is the potential for uneven distribution depending on where the pipes are built | This would be very helpful for the environment as it would reduce the amount of wastewater that is treated and released into nature     | It is a long term solution that would prove useful no matter how supply and demand change over time | Difficult to alter this option after pipelines are built |
| Water Re-Use (Supply Side Management)   | It directly addresses the supply issue and allows for demand to increase             | Upfront costs are expensive but it will be cost effective in the long run                                   | If the upfront costs can be managed, technical considerations are minimal                                                                      | There is the potential for uneven distribution depending on where the pipes are built | This would be very helpful for the environment as it would reduce the amount of wastewater that is treated and released into nature     | It is a long term solution that would prove useful no matter how supply and demand change over time | Difficult to alter this option after pipelines are built |
| Permitting (Supply Side Management)     | Regulation would be highly effective if funded to its fullest                        | Regulation would not be cost-beneficial because the costs of monitoring and enforcement would be exorbitant | There will likely be political resistance to this from the farm and energy lobbies                                                             | Regulation would be equitable                                                         | Regulation may or may not increase environmental health and safety goals because water scarcity policies may not rank EHS as a priority | This policy could be long term if the costs can be managed on a long term basis                     | This alternative would be very flexible                  |

|                                          |                                                                                                            |                                                                                                                 |                                                                                                                                      |                                                                                         |                                                                                 |                                                                                                                                         |                                                                                             |
|------------------------------------------|------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Conservation<br>(Demand Side Management) | Alone this will not meet the growing demand from consumers                                                 | Depending on the type of conservation management undertaken, this alternative may or may not be cost efficient. | Technologically this will be feasible. However, this will only be politically feasible if it is shown to be efficient and effective. | This can involve all stakeholders at some level                                         | This could help EHS if all stakeholders participate.                            | Establishing habits now will increase likelihood of conservation habits persisting into the future through generational culture changes | This alternative could be easily altered.                                                   |
| Water Market<br>(Demand Side Management) | Effective if the market accurately captures the cost of environmental degradation.                         | High cost to firms, moderate implementation and administrative cost to govt.                                    | Low political feasibility. Moderate cost of paying higher rates may lower capital capacity to deploy new technologies                | Very Equitable.                                                                         | If priced effectively, policy will reduce overall EHS risk.                     | Prices reflect current supply and demand not long-term forecast                                                                         | Prices will change to reflect supply at a given time                                        |
| Education<br>(Demand Side Management)    | Will not directly result in water use reductions, but will be crucial in successful policy implementation. | Relatively low cost.                                                                                            | Highly feasible                                                                                                                      | Broad public and stakeholder engagement will improve perceived equity of policy choices | Will help to protect EHS in all aspects, not only in water quantity and quality | This can be a long policy option.                                                                                                       | This policy option is very flexible. Time, place, and content can be changed fairly easily. |
| Water Price<br>(Demand Side Management)  | Effective if the price accurately captures the cost of environmental degradation.                          | High cost to firms, low cost to govt.                                                                           | Low political feasibility. Moderate cost of paying higher rates may lower capital capacity to deploy new technologies                | Depends on the type of water pricing chosen                                             | If priced effectively, policy will reduce overall EHS risk.                     | Prices reflect current supply and demand not long-term forecast                                                                         | Prices will change to reflect supply at a given time                                        |

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