

Investigation of Domestic Water Consumption in the Sports and Health Center at
the University of Minnesota-Duluth

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Definitions

To clarify how this research paper uses certain words and phrases in the context of water usage within the scope of this project, a list of definitions is included as a benefit to the reader to better understand the authors' use and interpretation of these terms.

Cubic Feet: The standard measure of water used in this presentation. One cubic foot equals approximately 7.5 U.S. gallons. Where cubic feet are not used, measurements are presented in U.S. gallons. One U.S. gallon equals 128 ounces.

Domestic Water: Treated water that comes in contact with humans to support everyday life.

Economic Impact: Any increase or decrease in the productive potential of the economy. Economic impact extends beyond the boundaries of any single organization and is linked to both the environmental and social elements of sustainable development. By understanding economic impact, we seek to understand how a resource adds value to society (CommDev, 2010).

Environmental Economics: The science of allocating scarce (finite) resources to unlimited (infinite) uses according to a valuation system that prioritizes social utility as opposed to individual utility and rewards renewable and sustainable projects over financial speculative projects that currently dominate the market capital system (Whitehead, 2007).

Environmental flow requirements: The quantity, quality, and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems (University of Twente, 2010).

Environmental Impacts: Effect caused by human activity or natural phenomenon on an environment that is related to or dependent upon water.

Fixture (Plumbing Fixture): A device that allows for the distribution and use of water within the Sports and Health Center. Examples include but are not limited to: faucets, showerheads, toilets, urinals, etc.

Glocal: The term used for "thinking globally, and acting locally".

Social Impacts: The consequences to human population of any public or private actions related to water that alter the ways in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society.

Impact Evaluation Criteria: “Water efficiency is the long-term ethic of saving water resources through the employment of water-saving technologies and activities. Using water efficiently will help ensure supplies for future generations.” (U.S. EPA, 2010)

Responsible Water Consumption: Personal and individual behavior of choosing to use only the amount of water needed.

To waste water: (*v.*) To use, consume, spend, or expend water thoughtlessly, carelessly, or purposefully (Houghton Mifflin Company, 2009).

Water consumption: The volume of freshwater used and then evaporated or incorporated into a product. It also includes water abstracted from surface or groundwater in a catchment and returned to another catchment or the sea (University of Twente, 2010).

NOTE: Water consumption and Water use are synonymous and represent any and all water utilized in SpHC, which includes water that is and is not returned to the Earth’s water cycle.

Water Efficiency: Relates to the institution’s efforts to install and utilize high efficiency water-saving technologies.

Introduction

The study aims to develop and conduct an investigation of the total domestic water consumption in the Sports and Health Center (SpHC) on the University of Minnesota-Duluth (UMD) campus. The investigation methods include collecting data from internal and external resources via interview, photography and internet-based research. Researchers will analyze data that reflects the current water consumption in SpHC and provide potential solutions to responsibly and sustainably consume water.

The University of Minnesota-Duluth is located in Duluth, Minnesota along the western shore of Lake Superior. Lake Superior holds approximately 10 percent or three quadrillion gallons of the world's fresh surface water (MN Sea Grant, 2008). This water-rich region has been predominantly unaffected while other regions of the United States and the world face water shortages. Through our research, our team aims to bring awareness to UMD and the local community about the importance of responsible water consumption in the Sports and Health Center and use this as a representative model for responsible water consumption in the community. Threats to Lake Superior water volumes include irresponsible and non-sustainable consumption and considerations of selling the water.

SpHC's homepage describes the building: "The 46,000-square-foot facility has two exercise rooms, a 37-foot climbing wall, a recreational gymnasium, a two-level cardiovascular fitness center, and offices for the Recreational Sports Outdoor Program." (UMD). In addition, the building houses a six-lane lap swimming pool, therapy pools for athletic teams and the athletic training program, multiple locker rooms, a full-sized ice rink, and many classrooms. The building's hours of operation are 6:30 a.m. until midnight during the school year and 6:30 a.m. until 10 p.m. during the summer months (Latto, 2006). The building is utilized somewhat differently during the summer months because of summer camps taking place in SpHC (Stevens, a personal communication, 2010).

Problem Identification and Definition

According to the United States Geological Survey, 97% of water on the Earth is salt water, leaving only 3% as fresh water of which slightly over two-thirds is frozen in glaciers and polar ice caps. The remaining unfrozen fresh water is mainly found as groundwater, with only a small fraction present above ground or in the air. It is important to know that 87% of the ground water comes from lakes (Gleick, 1996). Virtually all water usage for human activities—agriculture, industry, recreation and household use—requires fresh water. How do people consume water in this water-rich city of Duluth? The identification of the research is the total domestic water consumption in SpHC. Can this amount be reduced? If so, how and by how much can it be reduced? If not, why? The definition of the issue is the potential over-use of water in SpHC.

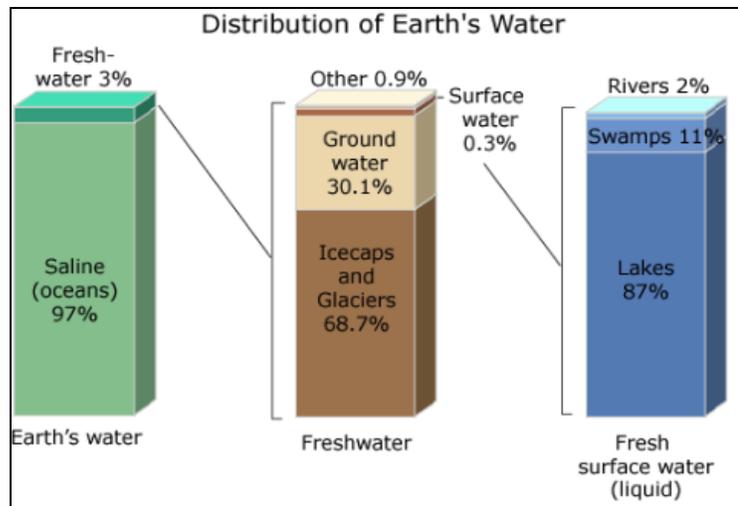


Figure 1: Distribution of Earth's Water (USGS, 2009).

Impact Evaluation Criteria

According to the US Environmental Protection Agency, “Water efficiency is the long-term ethic of saving water resources through the employment of water-saving technologies and activities. Using water efficiently will help ensure supplies for future generations.” The Impact Evaluation Criteria to determine what level of water consumption SpHC is at includes applying the EPA’s definition of water efficiency, determining baseline water requirements needed for the building to function, and determining if more than this baseline amount of water is being used.

Global Data and Research

Methods

Data collection for global water data was conducted via the Internet.

Data

To assess the extent and impact of water consumption in SpHC, our team will look at water consumption in two parts—globally and locally—to determine how SpHC water consumption plays a role in the global issue of water use. Because the research is being conducted close to Lake Superior, it is important to bring attention to the value of Lake Superior water in the larger picture of water consumption. Figure 2 shows the layering involved in our research of water as an environmental issue at different levels.

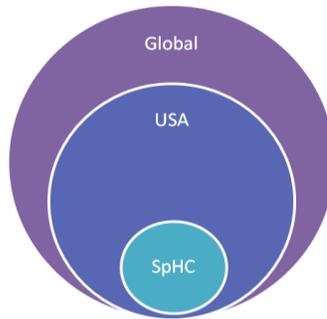


Figure 2: Model of the three levels involved in water consumption discussed in this report.

Globally, we will research and collect data regarding:

- What water is used for (worldwide, USA, SpHC)
- Water usage comparisons among various countries
- Timeline prediction for water shortages based on current rate of use

Worldwide, the uses for water are similar. Agricultural, Industrial, and Domestic water use are compared in Figure 3 below.

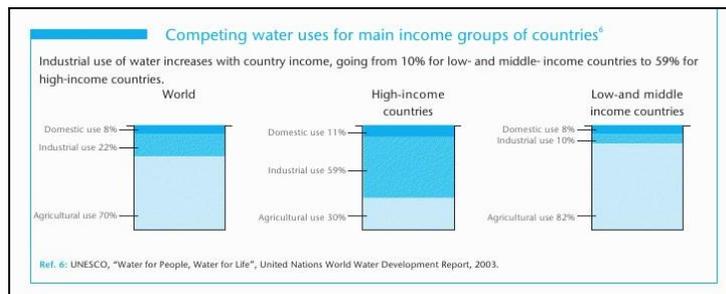


Figure 3: Competing water uses for main income groups of countries (WCBSD, 2009).

However, the amount of water used per capita varies greatly. Humans need a minimum of two liters of drinking water per day to survive, which is less than one cubic meter per year. The data from World Business Council for Sustainable Development in Figure 4 shows a comparison of average per capita domestic water consumption of different nations.

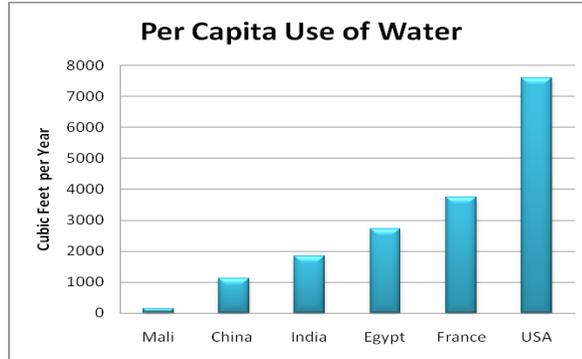


Figure 4: Average per capita domestic consumption from different nations (WBCSD, 2009).

Impacts

The impacts of water consumption can be assessed environmentally, economically, and socially.

Water availability is an environmental issue worldwide. However, as mentioned previously, some regions are affected more than others as seen in Figures 3 and 4 above.

On a global level, economic impacts due to water consumption do exist. In a January 2010 article by Dan Jones in *Power & Energy* magazine, Jones writes, "... a lack of access to water is likely to change the economic environment irreparably and also has a vital role to play in the power and energy sector as water is required for many of the power sources vital to both our present and our future. Boiling water can be used to drive turbines, supply coolant for nuclear power and even in oil production."

Other economic impacts related to water consumption include the cost of building and maintaining necessary infrastructures. For example, David Boyd of the Organization for Economic Cooperation and Development in Canada states, "On the economic side, high levels of water use require ever-increasing and expensive investments in water system infrastructure needed to gather, deliver and dispose of water (dams, reservoirs, water treatment facilities, distribution networks and sewage treatment)."

Social impacts related to water consumption on a global level include the public health, population growth, economic development, social justice and welfare of a country. According to Unicef's webpage of Children and Water: Global Statistics, lack of safe water and sanitation is the world's single largest cause of illness. In 2002, 42% of households worldwide had no toilets, and one in six people had no access to safe water. And, urban-rural disparities are striking. In 2002, only 37% of rural inhabitants had access to basic toilets, versus 81% of urban dwellers. The disparities were greatest in Latin America and the Caribbean, with a difference of 40% between rural and urban population (Unicef, 2006). According to WaterFootprint.org, "More than 2.8 billion people in 48 countries will face water stress or scarcity conditions by 2025." Fig. 5, a snapshot from WaterFootprint.org's website, shows worldwide statistical water information.

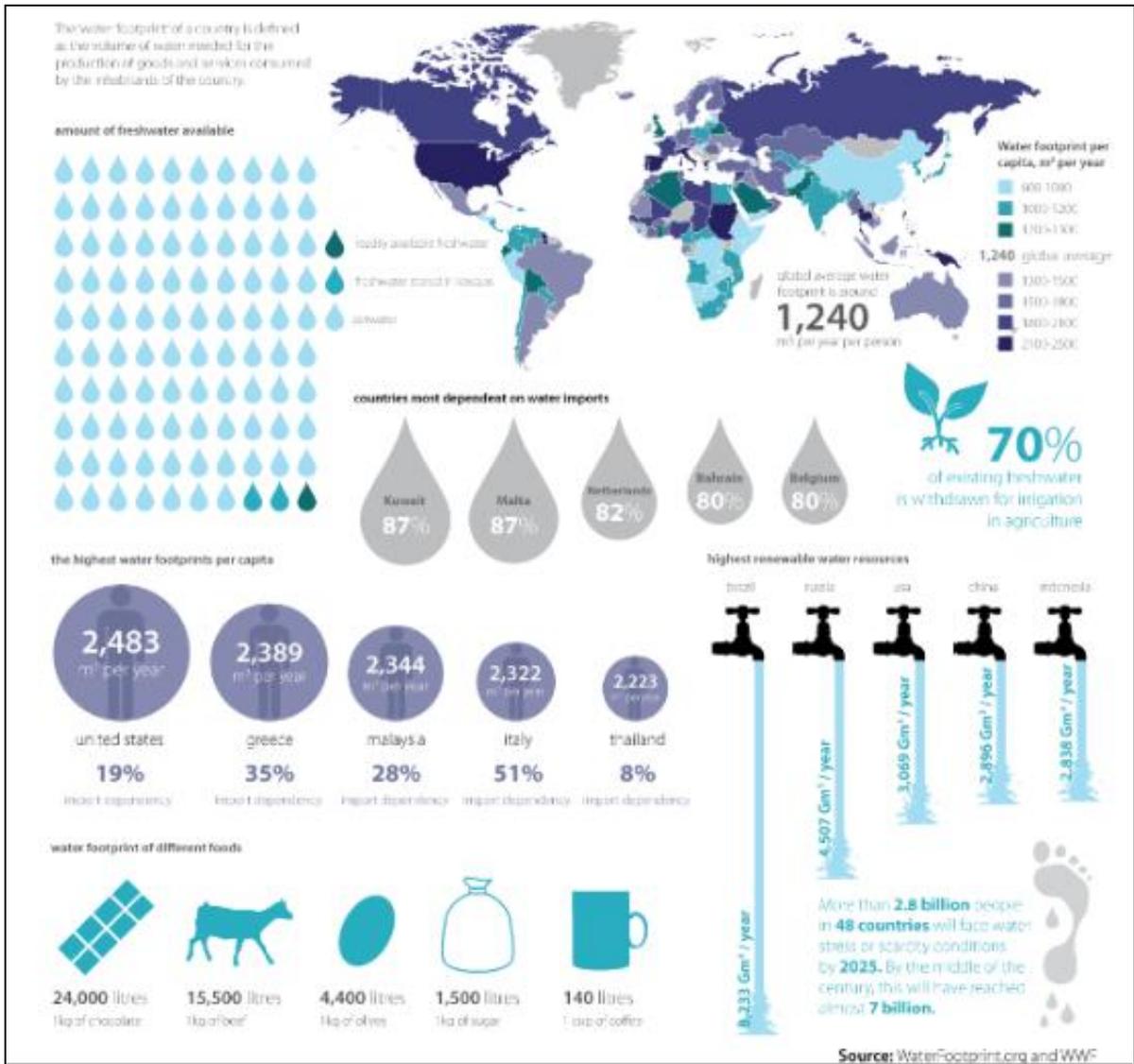


Figure 5: Statistical water information from University of Twente, 2010.

Case Study: Aral Sea

It is hard to imagine Lake Superior being empty. To capture this image one can look at the Aral Sea, a once plentiful inland water resource to the Soviet Union. The Aral Sea is set between Uzbekistan and Kazakhstan. When full, it was the fourth largest inland sea in the world covering 26,254 square miles. It is now 10% the original size; 2,625 square miles and shrinking.



Figure 6: Ship sits on dry land in a once water-rich Aral Sea (LeMay, 2009).

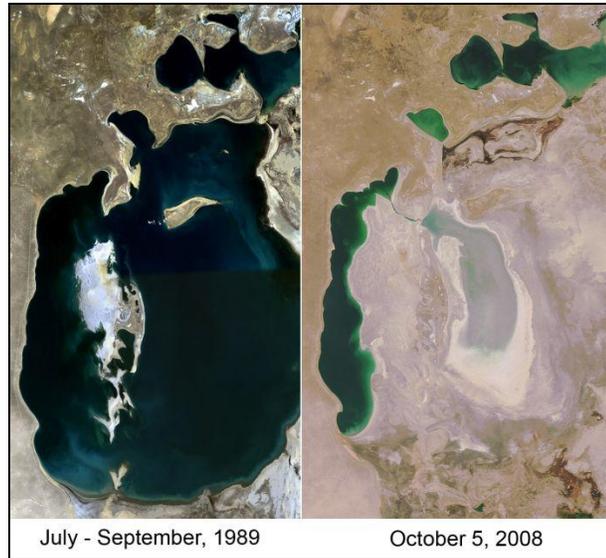


Figure 7 : An aerial view of the Aral Sea shows the decrease in water from 1989 to 2008 (LeMay, 2009).

The environmental effects of this disappearing lake include species depletion and an increase in harmful pollutants. These two major effects are the same that could occur if Lake Superior began to deplete. As the water retreats from the shore, fish begin to lose their spawning ground. The pollutants become more concentrated as water is lost. The pollutants do not remain only in the water left behind but in the land, once under water, that has become exposed. As this land dries up, the pollutants become airborne and can cause respiratory problems.

The climate of a region is also greatly affected by the decreased volume from a lake similar in size to Superior. As the Aral Sea lost more water volume, the temperature of the water increased. It was easier for the sun to warm the waters and maintain those warmer temperatures. The water absorbs heat from the sun in the summer and holds it through the winter (LeMay, 2002). Loss of water will increase the air temperature on the coastal areas in the summer and decrease the air temperature of coastal zones in the winter. Additionally, decreased species diversity occurs due to the water's temperate shift outside of particular species' temperate zones. Warmer water may also allow for exotic species to make their home in these affected waters.

Local Data and Research

Questions Identified to Guide Data Collection

Internal Questions

The main body of data will be collected on campus guided by the following questions:

- What is the layout of the water pipe system in the SpHC building? How long are the pipes? How far must water travel from the heating/cooling source? Is it possible to separate and reduce the distance to transport hot and cold water? Is it possible to assess water usage in individual areas of SpHC? (Locker rooms, pool, rest rooms, ice rink, etc.)
- What is the layout of the entire UMD water system? How is it related to other buildings?
- Is there any established water recycling system in SpHC or elsewhere on the UMD campus?
- How long it will take before you get hot water when taking a shower or washing hands?
- What brands or companies is the main water machinery (boilers, pumps, pipes, etc.) supplied by?
- How many types of water appliances are being used here in SpHC? Shower, toilet, faucet, etc? What are they? Identify the basic functions. Determine if these are designed to conserve water or if they can be changed to do so.
- Are there specific areas in SpHC that should be targeted for improved water efficiency?
- On average, how much money is spent on water consumption in SpHC and/or UMD depending on billing/tracking each year (or a given time period available from billing/tracking)?
- What are the restrictions or difficulties faced in renovating any facilities in need? Why?

External Questions

To better understand the issue, three types of questions are listed to learn more about the water system leading to UMD. The first is a general overview of the water system in Duluth. Second, what type of connection exists between UMD and the city? And third, what are some exemplary models and data collection that can be referenced?

- What type of water system does the City of Duluth provide?
 - Is there a visual aid that we can see to understand the layout?
 - Is this similar to other water systems in Minnesota? In the United States?
- What happens to used water (sewer water)?
 - Where does it go?

- What happens to it before it gets there?
- Is there a recycling system?
- How is UMD connected to the city water supply?
- Are there any exemplary models used elsewhere that we can learn about?
- Is there statistical data on water usage?
 - City of Duluth?
 - UMD?

Methods

Internal Questions

We will meet with whomever is in charge of SpHC as a starting point to find out who is familiar with the facility and can provide factual data about the water usage, water supplier, and water treatment system. For example, this could be the manager of facilities in SpHC. The research group will interview individuals with proper access to certain areas of SpHC (boiler room, pool area, etc.) Finally, the research group intends to meet with someone who can provide financial statistics (i.e. billing) that reflects costs associated with water consumption in SpHC, because finances often act as a determining factor for change or staying the same. We also want to know the cost of equipment, appliances, etc. to understand the "hidden costs" involved in water consumption.

Potential interview candidates include the following individuals (in alphabetical order):

- Gregg Batinich, Aquatics Director
- Linda Bloom, Accounts Payable
- Mindy Granley, Sustainability Coordinator
- Eric Larson, Facilities Management
- Chris Stevens, Sport Facilities and Event Supervisor
- John Sawyer, Facilities Management
- Roger Worthing, Mechanic 2, Facilities Management

External questions

In relation to the City of Duluth, we would like to understand the connection between UMD and the city water system and the costs involved therein, so someone who is knowledgeable in this area will be helpful. Specifically, we contacted a representative of Comfort Systems/Public Works and Utilities who was willing to provide further information on this research question. We also conducted internet research to find useful background information about the city water system in Duluth, exemplary models for responsible water consumption, and information regarding impacts, results, and solutions regarding water consumption. Ideally, our team will learn how other similar institutions handle water consumption.

External from UMD, the following individual will be interviewed for information about the City of Duluth water system:

- Howard Jacobson, Manager of Water and Gas Distribution

Data Collection and Analysis

Locally, we will research and collect data regarding:

- Water usage per person per day
- Awareness of possible areas in SpHC that are or could be major water users (locker rooms, rest rooms, pool, ice rink, etc.)
- Water meter data for SpHC (hot, cold, steam)
- Water flow for each water fixture (shower heads, faucets, toilets)
- Are there ways to improve their efficiency?

Overall, Minnesota is considered a water-rich region. Duluth, in particular, uses water from Lake Superior to meet the domestic and industrial needs of the city. Figure 8 below shows the categorical proportions of water usage in Minnesota in 2005.

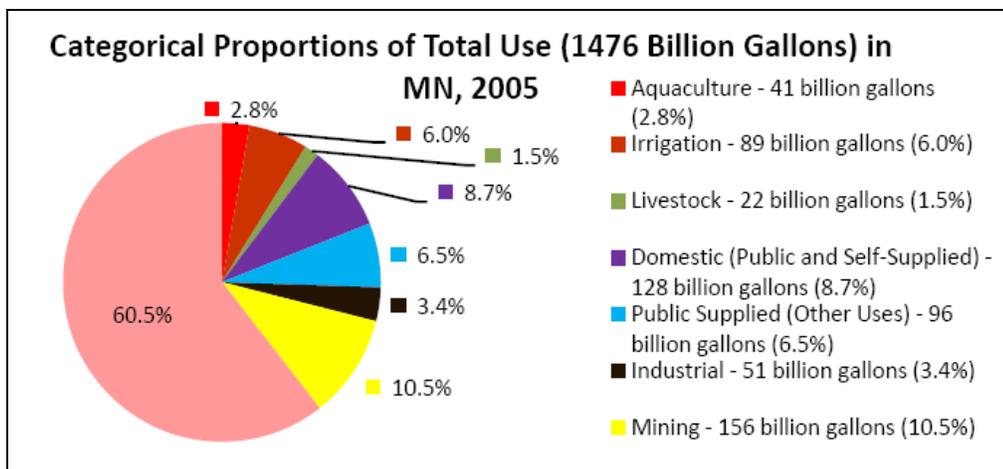


Figure 8: Minnesota Water Use by Category, 2005 (Fairbairn, 2009).

NOTE: The light pink portion represents Thermoelectricity.

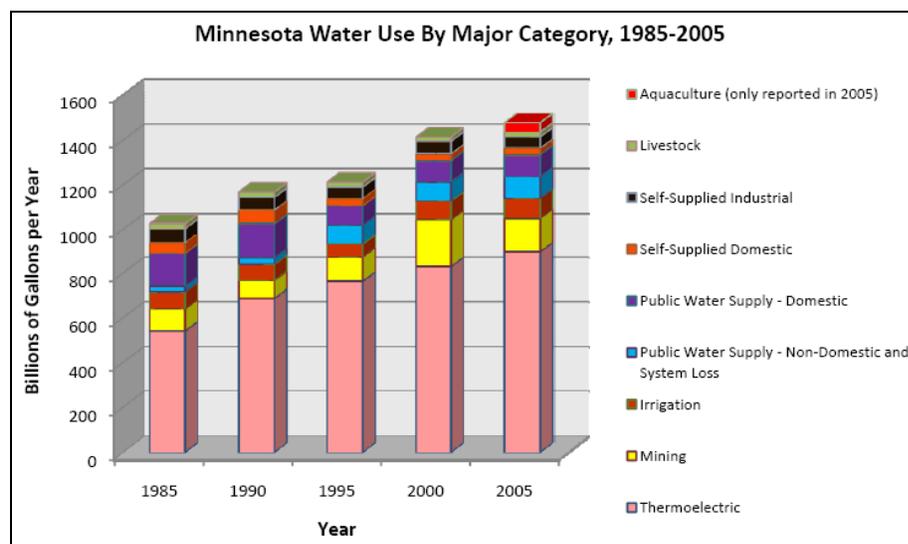


Figure 9: Minnesota Water Use by Category Over Time, 1985-2005 (Fairbairn, 2009).

According to David Fairbairn of the University of Minnesota, the national per capita average of consumptive water use per day in the United States in 2005 was 98 gallons. Minnesotans rank lower than the national average, with a per capita average of 68 gallons. Of the Minnesotans using publicly supplied water, 69% received their supply from surface water while the other 31% received it from ground water (Fairbairn, 2009).

In Duluth, surface water is drawn from Lake Superior for public water supplies. The UMD campus receives its water supply from multiple inlets located around the campus perimeter. There are two sources of water coming into the building. The primary source has two pipes, one is 8” and one is 10” in diameter. The secondary source enters through the back of the building and is not metered by the City of Duluth, and therefore is only used when the primary water pipes are not available. (Sawyer, a personal communication, 2010). Once these inlets enter the building, they branch out into an extensive plumbing system that has been expanded with each of the building’s expansion projects. Both hot and cold water are used domestically in various areas of SpHC. One 15” waste water pipe carries all waste water out of SpHC. Appendix II shows a schematic of the water system for SpHC.

Our team collected available pertinent information of water usage in the Sports and Health Center as shown in Table 1 and Figures 10 and 11.

Amount of water used in primary water-consuming areas of SpHC	
Showers	2.0 or 2.5 gpm depending on brand
Faucet	0.5 gpm
Toilets	1.6 gallons per flush
Urinals	1 gallon per flush
Pool	136,000 gallons to fill it, minimal loss and add-in based on chemical mixing, evaporation, and leakage
Cooling Tower	See Fig. 6: SpHC Cooling Tower Water Use by Month and Fig. 7: SpHC Cooling Tower Annual Water Use
Ice rink	200'x100' sheet of 1" thick ice is 20,000 gallons Avg of 80-100 gallons for resurfacing.
NOTE: Complete data is not available for every area of SpHC that uses water. This table represents data that is currently available.	

Table 1: Water Usage in SpHC. (Sawyer, 2010), (Russel- Ausley, 2000) & (Stevens, 2010).

Ice Rink and Cooling Tower

SpHC houses a full-size ice rink that is used throughout the year. According to Chris Stevens, Sport Facilities and Event Supervisor, the ice sheet is maintained the majority of the year and used for a number of different activities. Stevens notes some of these activities, such as hockey camps, generate revenue for the university (Stevens, a personal communication, 2010). An external cooling tower plays a role in maintaining the 200'x100' sheet of ice at a thickness of 1" and data for water use in that tower has been monitored since 2007. Figures 7 and 8 show the cooling tower's water usage patterns from 2007-2009.

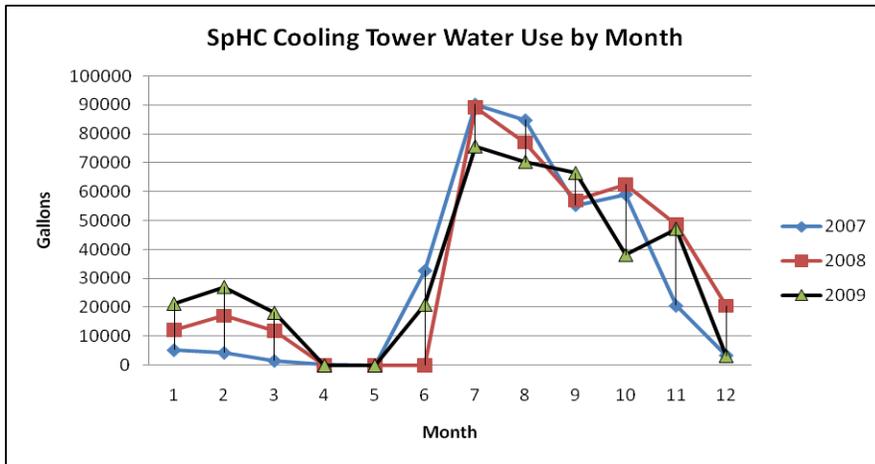


Figure 10: SpHC Cooling Tower Water Use by Month (Sawyer, 2010).

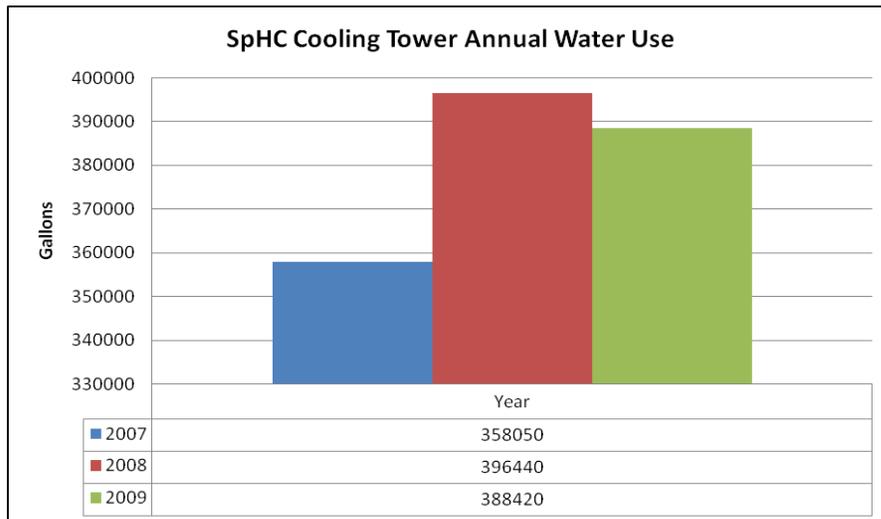


Figure 11: SpHC Cooling Tower Annual Water Use (Sawyer, 2010).

Based on data presented in Table 10 and Figure 11, one can compare the water usage for flooding and resurfacing the ice rink against the water used by the cooling tower. Data for the average or total number of resurfaces of the ice rink were unavailable at the time of this report.

Pool

The indoor swimming pool housed in SpHC was built when the original building was constructed in 1953. A number of assumptions have arisen regarding the leakage of pipes linked to the pool and the ventilation system in the pool deck.

The six-lane swimming pool has a capacity is 136,000 gallons of water. One could fit 3 SpHC rooms in the pool. The water is collected, filtered and then re-circulated into the pool. There are two major operations in the pool that contribute to the amount of the water in the pool. The largest contributor is the pool's water exchange operation which is made up of a surge tank collection system, a filtration tank system and a lot of pipes and pumps.

The majority of the information collected about the pool came from Roger Worthing during an interview and tour in 2010. Water from the pool is collected and exchanged beginning with a surge tank. Surge tank is located on the bottom most layer of the building. The surge tank is a water overflow tank built of concrete blocks. The pool itself also rests on the bottom most level of the building; this helped dispel myths of the pool falling through the floor. Being located under the pool allows gravity to pull water from the pools' drains and "fall" down to the surge tank for holding. It collects water caught from the scum drain along the sides of the pool, also known as skimmers. About 40% of the surge tank's water comes from the scum gutter. The other 60% is composed of water collected by 2 drains at the bottom of the pool. These drains are located in the deep end of the pool. (This is common practice because the pool floor on deeper ends of pools are touched less by patrons.) It is important that more water is taken from the bottom of the pool so less domestic water is used/added.

Domestic water is added to the surge tank if not enough water is being collected from the pool. There is a float system in place similar to that in a toilet tank. If the water levels drops past the floater a sensor activates the pipe of the cold domestic water supply to add more until the floater is once again touching the water surface.

After water is drained into the surge tank it is pumped out into one of 2 insulated pipes. Water moving out of surge tank is pumped through insulated tubes with steam heat to heat the water up to 83° F. This warmed water is pumped up to the Filtration tank at pool level. The pool has its own steam heat system, with two steam converters as backup to the pool pack unit. So heating the pool area is not part of the domestic water supply.

Water begins the filtration process by first being pumped into the filtration tank which also uses a float system to maintain water level. Water is filtered through plastic framed filters with nylon covered sheets that are coated with diatomaceous earth. Water moves through the flat face and out a hole at bottom of each filter.

Nylon sheets are reusable; they can be washed after each use. UMD keeps a full set cleaned and ready to use on hand at all times. There are 3 sets, one being used, one on deck and one being washed in between stages.

Before filtered water enters the pool, the Oxygen Reduction Potential (ORP) is checked as well as pH by sensors on the pipes outside of the filtration tank. ORP is kept at 711 mV and pH is kept at 7.6.

If chlorine levels in the pool reach too high, the water becomes more acidic, with pH levels being too low; Soda Ash is basic material and is added to

raise the pH. Sodium bicarbonate is used to raise alkalinity. Pool is kept at (80-150ppm). Sodium bicarbonate helps make the pH more resistant to change.

If pH becomes too high, chlorine gas is the form of chlorine that enters the water when needed to add to the pool. For safety reasons the holding tank of the chlorine gas is kept outside of the building and enters through piping. Chlorine gas is drawn from the tank into injector (part of the venture system).

A safety feature to protect against the deadly poisonous chlorine gas is the pipes which hold any chlorine in gaseous state are pressurized by a vacuum. This creates 0 pressure in the pipes so if any or opened, chlorine gas won't spill out. Instead, the higher surrounding air pressure will push into the pipe.

Ventilation

In March 2010, the indoor pool's ventilation system was repaired. The repairs are expected to improve air quality and control humidity in the pool area. Based on a study conducted by Charles E. Smith, et al, evaporation rates for active indoor pools are dependent on a number of variables. These variables are "...correlated with vapor pressure, humidities, and air velocity," (Smith, 1998). The evaporation calculation Smith cited for active indoor pools is found below.

With the current ventilation system the air in the pool facility is 50% humidity. The air now is less humid than it used to be. This was a problem in water conservation because it causes water to evaporate from the pool.

The Pool Pack Unit pulls air out of the pool natatorium, dehumidifies, and adds heat. The installation project cost \$7-8000 and was done in March 2010. The pool pack unit is made by the same manufacturer as the unit used by The Water's Edge, an indoor water park in Duluth. The pool pack is automated to control the temperature and humidity of the natatorium (pool area) and replaces the former roof top unit, which was highly inefficient and not conducive to Duluth' year-round climate.

The old system took a lot more energy. The old system was built for southern climates. The features and highlights looked good on paper, but bad in practice. One reason being, 100% of air was taken from outside (that's a lot of reheating of air in MN winter temperatures). New system is much more convenient and only takes 10% outside air for exchange.

$W = (69+0.35 v)(p_w-p_a)/Y$	
W	= evaporation rate, lb/h-ft ² (pounds per hour per square foot)
v	= air velocity at water surface, ft/min
p _w	= saturation vapor pressure at water temp, in Hg (inches of Mercury)
p _a	= saturation vapor pressure at air dew point, in Hg, also partial pressure of water in pool atmosphere
Y	= latent heat at pool temperature, Btu/lb (British thermal unit per pound)

Figure 12: Rates of Evaporation from Swimming Pools in Active Use (Jones et al, 1998).

Calculations vary depending on the amount of use a pool is experiencing, and a second calculation would represent the amount of evaporation on an inactive pool. Within the scope of this research project, the SpHC pool is considered inactive when it is not being used. According to Smith, inactivity decreases evaporation (Jones et al, 1998).

Impacts

This report assesses one building's impact of water usage on environmental, economic, and social levels.

The Sports and Health Center is one of the oldest buildings on the UMD campus. It was constructed in the 1950s and received additions in the late 1980s and the early 2000's. Because the building's infrastructure is somewhat 'old' it is also considered inefficient relative to modern standards.

Environmental Impact

Environmentally, Lake Superior is the primary body of water the Duluth area is focused around. Water used in SpHC is drawn from Lake Superior. While some of that water is cycled back out through the water treatment facility and into the lake, not all of it is. Water, especially fresh water, is a finite resource. Lake Superior's natural gain of water is from snow melt, runoff from streams and ground water and precipitation. A usual annual gain for Lake Superior is 2.3ft. of rain or snow and about 1.8ft. flows from streams and groundwater. That's roughly about 4 feet total gain. Natural loss of water in Lake Superior is from evaporation, about 1.6ft., and about 2.5ft. of water flowing into St. Mary's river and Lake Huron (LeMay, 2009).

An environmental effect of the water volume decreasing in Lake Superior include; an impact on wildlife and plant species. Due to the change in water level, descending shoreline and changes in water qualities (temperature, oxygen levels, and pollutants), wildlife and plant species in the Lake Superior coastal region could be lost (LeMay, 2009).

Human factors that also affect the water levels include; diversions into or out of the drainage basin, consumption of water, dredging of outlet channels and the regulation of outflows (outflows in the Great Lakes system are regulated on Lake Superior and on Lake Ontario) (MN Sea Grant, 2008).

Due to the size and geographic location of Lake Superior and the other great lakes, water volumes and quality are of importance to a number of U.S. states as well as Canadian provinces. Commenting specifically on the Great Lakes Basin, the Canadian Environmental Law Association (CELA) states: "Changing water levels and flows will have unpredictable and harmful consequences to basin habitat, biodiversity, shorelines, jobs and culture, particularly to First Nations. Lower water levels will mean greater disturbance of highly contaminated sediments in shallow harbours and connecting channels and less dilution of polluted waters," (CBC News Online, 2008).

Economic Impact

An economic impact of water consumption in SpHC is represented by the possibility of paying for more water than is needed for the building to function. Fig. 9 below shows the Monthly Water Rates for the City of Duluth. According to John Sawyer, Principal Engineer Supervisor, UMD Facilities Management, no current exact data exists for the total amount of water regularly consumed in

SpHC. Therefore, it is difficult to measure the building’s overall water use. Based on rates published in January 2010 in the *Comfort Systems Water, Sewer and Natural Gas Service Rates* brochure provided by Howard Jacobson, non-residential water rates for the City of Duluth start at \$2.56 per 100ft³ up to 4,000 ft³. After that, prices decrease in proportion to the increase in water purchased. In addition, monthly sanitary sewer service rates are incorporated into the charges.

WATER, SEWER, STORM WATER AND NATURAL GAS SERVICE RATES		
MONTHLY WATER RATES –		
Effective with meter readings after February 1, 2009		
Fixed monthly charge varies with size of meter. For meters 1" and under		\$3.50
First 4,000 cubic feet, per 100 cubic feet		\$2.56
Next 96,000 cubic feet, per 100 cubic feet		\$1.67
Next 900,000 cubic feet, per 100 cubic feet		\$1.39
Over 1,000,000 cubic feet, per 100 cubic feet		\$1.15
Water for individuals beyond city limits, per 100 cubic feet		\$3.87
MONTHLY SANITARY SEWER SERVICE RATES –		
Effective with meter readings after February 1, 2009		
Fixed charge, \$5.89 per month		
Class I Customers (Residential) - per 100 cubic feet of water consumed		\$5.02
Class II Customers - per 100 cubic feet of water consumed		\$6.97
Class II Customers - per 100 cubic feet of water consumed		\$8.59
MONTHLY NATURAL GAS RATES –		
Effective with meter readings after October 1, 2009		
Gas sales services for each 100 cubic feet of natural gas consumed		
	<u>Fixed Monthly Charge</u>	<u>Per 100 Cubic Feet</u>
Residential Firm		
Rate 10 Small Volume	\$7.50	\$1.241
Rate 15 Large Volume	\$200.00	\$1.140
Commercial / Industrial Firm		
Rate 20 Small Volume	\$40.00	\$1.157
Rate 30 Large Volume	\$200.00	\$1.127
Commercial / Industrial Interruptible		
Rate 50 Large Volume	\$450.00	\$1.005
Commercial / Industrial Interruptible Transport First Year Rates		
Rate 80 Small Volume	\$40.00	\$0.1881
Rate 90 Large Volume	\$450.00	\$0.1661
MONTHLY STORM WATER RATE* –	Effective after January 1, 2008	(per ERU) \$6.08
MONTHLY CLEAN WATER SURCHARGE* –	Effective after August 1, 2009	\$8.78
MONTHLY STREET LIGHTING CHARGE –	Effective after December 1, 2008	\$3.50
*rates effective with meter readings after the date listed		

Figure 13: Comfort Systems Water, Sewer and Natural Gas Service Rates published in January 2010.

In ranking UMD’s utility bill, Sawyer indicates that water costs are almost insignificant compared to Natural Gas and Electricity, and he states, “It is hard to make people make changes when they are not financially motivated.” As shown in Figure 14 below, water costs represent 6 percent of the total UMD utility bill, which averages in total \$4.8-6.5 million/year, which amounts to \$288,000-\$390,000 annually (Sawyer, a personal communication, 2010) (Stevens, a personal communication, 2010). The challenge our team encountered, however, is that the actual economic impact of domestic water usage in SpHC specifically is unknown due to the lack of water meters on water mains leading into the building or on cold water pipes within the building.

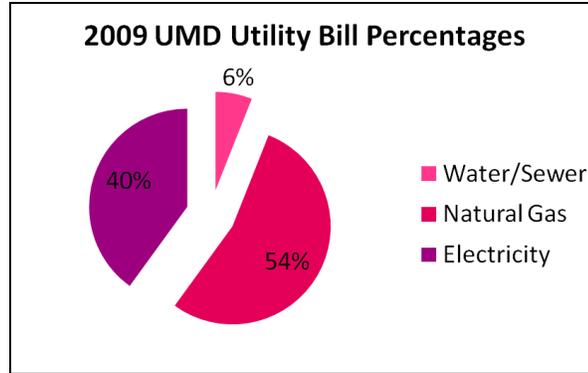


Figure 14: 2009 UMD Utility Bill Percentages (Sawyer, 2010)

Locally, the water levels of Lake Superior affect the shipping industry, which is followed by a domino effect on other impacts related to the economy. “For the shipping industry, a one-inch (2.5 cm) water level drop can mean over 250 tons of coal will be left on the dock when a thousand-footer weighs anchor. A two-foot drop means that upwards of 6,000 tons, approximately ten percent of a thousand-footer's capacity will be left behind.” (MN Sea Grant, 2009) Shipping is a main industry that contributes to Duluth's and the surrounding regions' economy.

Social Impact

How an institution consumes water reflects upon its reputation of positive social behavior and environmental responsibility. By social impacts our research team means the consequences to human population of any public or private actions related to water that alter the ways in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society. (The Interorganizational Committee on Principles and Guidelines for Social Impact Assessment, 2003).

Socially, U.S. population growth also contributes to water consumption. According to the US Army Corps of Engineers, “...In general, the country is using water more efficiently today than ever before, particularly in the agricultural industry. But the population of many U.S. cities is growing so fast that it is outstripping these efficiency gains, requiring communities to develop new water supply sources.”

In the city of Duluth, people fortunately have the benefit of clean, abundant water supplies from Lake Superior. According to Howard Jacobson, Operations Manager, Gas & Water Supply Department of Public Works & Utilities, fresh surface water pumped from Lake Superior directly to the Lakewood Water Treatment Plant enters the plant at a higher quality than some water products returned to the water basin after being treated.

Focusing on SpHC specifically, Stevens believes students are more aware of environmental issues now than they were years ago. He attributes his opinion to the students having grown up in a time when there has been more focus on environmentally-related issues. Stevens believes that it can sometimes be more challenging to convince faculty/staff to make changes than it is to convince students of making changes.

Recommendations

The research team does not propose that areas of SpHC stop using water. Instead, the research team aims to make recommendations for responsibly using water while ensuring these areas continue to serve their purposes.

Environmental Recommendations

Lake Superior's water levels are not a major concern at this point in time. That said it is still possible for it to become one in the future. A body of water of its size is hard to imagine it going anywhere anytime soon. One advantage to Lake Superior's greatness is the quality of water remaining. Howard Jacobson of Duluth Comfort systems said "...the quality of the water intake from Lake Superior is close to the quality that some water treatment facilities finish with."

Recommendations of water use in SpHC is to use as little as possible, put back what can be restored and make sure that returned water is as clean as possible. The water quality in Lake Superior is good and we should do what we can to keep it that way. What we do now preserves water in Lake Superior for the future.

Before water is put back into Lake Superior it is treated at Western Lake Superior Sanitary District (WLSSD). Here the water is filtered and treated. Although there is a water treatment plant, it doesn't mean that water consumers are any less responsible for preserving the environment. Although technology and science discovery has come a long way, miracles are not preformed at WLSSD. It is suggested that SpHC uses as few chemicals while cleaning and in the pool as possible.

Further research will include an investigation of the cleaning products and chemicals used in SpHC. Suggestions of better products or methods will be presented if least harmful practices are not already in place.

Economic Recommendations

Without actual data, it can be difficult to assess the overall economic impact of water utilities in SpHC. We recommend that UMD consider installing a meter on a section of 6" domestic cold water piping in the Mechanical Room in SpHC. This meter would complement the already installed meters on the hot water pipes and contribute to a sum total of hot and cold water usage for the building and a comparison between the two.

According to Sawyer, "A typical water meter up to 2-inches will run \$500-\$1000 for the meter. The total cost to install would be about double the meter cost". "Meters 2-inch to 4-inch would be about \$2000 and 6-inch could be as high as \$5000." Thus far, UMD has not installed meters on pipes larger than 6 inches [in diameter]. Instead, the meters are typically on smaller lines.

However, the hot water main already has a water meter installed, so only non-hot water mains would need meters (Sawyer, a personal communication,

2010). At the time of this report, the number of non-metered pipes was unknown and it is recommended this data be collected for a more comprehensive cost evaluation to determine whether two larger meters or multiple smaller meters will be more cost effective for monitoring domestic water use in SpHC.

In the meantime, as a standard move toward water conservation, we recommend the installation of low-flow water fixtures in any remaining areas of SpHC that do not already have such fixtures installed.

Social Recommendations

More transparency and clarity of water consumption in SpHC will be recommended so that people will become more aware of water conservation by exposure to the information. We suggest that signs be posted in the locker rooms and bathrooms in SpHC that explain the amount of water used per minute and the average water flow rates of the related fixtures. Our intention is to help people see the consequences and impacts to others when they over use water. We found that if one person shortens their daily shower by one minute then 5 gallons water will be saved. One person in a month will reduce the amount of water used by 150 gallons. Accordingly, 100 persons in 10 years will help save 18,000,000 gallons of water. Based on these calculations, we would propose a water conservation campaign called “Just One Minute” to reduce water consumption and increase responsible water consumption. This campaign could be used as a starting point for SpHC and the greater UMD campus to become more aware and responsible water consumers.

Pool Recommendations

Water meter could be installed specifically for the pool on a 3” water pipe that meters the domestic water supply into the pool (Worthing, a personal communication, 2010). This meter would measure only the pool’s water use and provide a way to measure water use longitudinally.

The Surge Tank could be redesigned to be larger to hold more overflow, which would reduce the amount of domestic water that ends up needing to be added in. For example, when there is a lot of activity in the pool (ex: The North Shore Swim Club).

Ice Rink Recommendations

The research team also would consider water quality to be a key factor in the efficiency of maintaining the ice rink. As our research indicates, better quality water leads to a better sheet of ice, which needs to be resurfaced less often.

Future Research

Water Boilers

Further, the water boilers in SpHC could form the basis for an entire evaluation and research project of their own to assess energy efficiency and its potential correlation to water consumption.

Water Fixtures

For further investigation of water efficiencies, our research team suggests collecting totals for each kind of water fixture in the building (i.e. no. of toilets, urinals, sinks, showers) to evaluate the overall efficiency of domestic water use.

Conclusion

All areas in SpHC that use water and were researched in this report need to continue functioning at the same level of use that they currently are at. Some of these areas, such as the ice rink, bring revenue to the university. At this time, the total domestic water consumption is not known. However, the research team has begun calculations for certain areas of the building and has recommended that meters are needed to provide actual numbered totals for the building and for certain areas of the building. Among our recommendations, we conclude that domestic water use can be reduced in certain areas of the building such as the locker rooms and the surge tank for the pool. The strongest recommendation we propose is to raise awareness of water use among the UMD community.

Appendix I: "Just One Minute" Campaign Poster

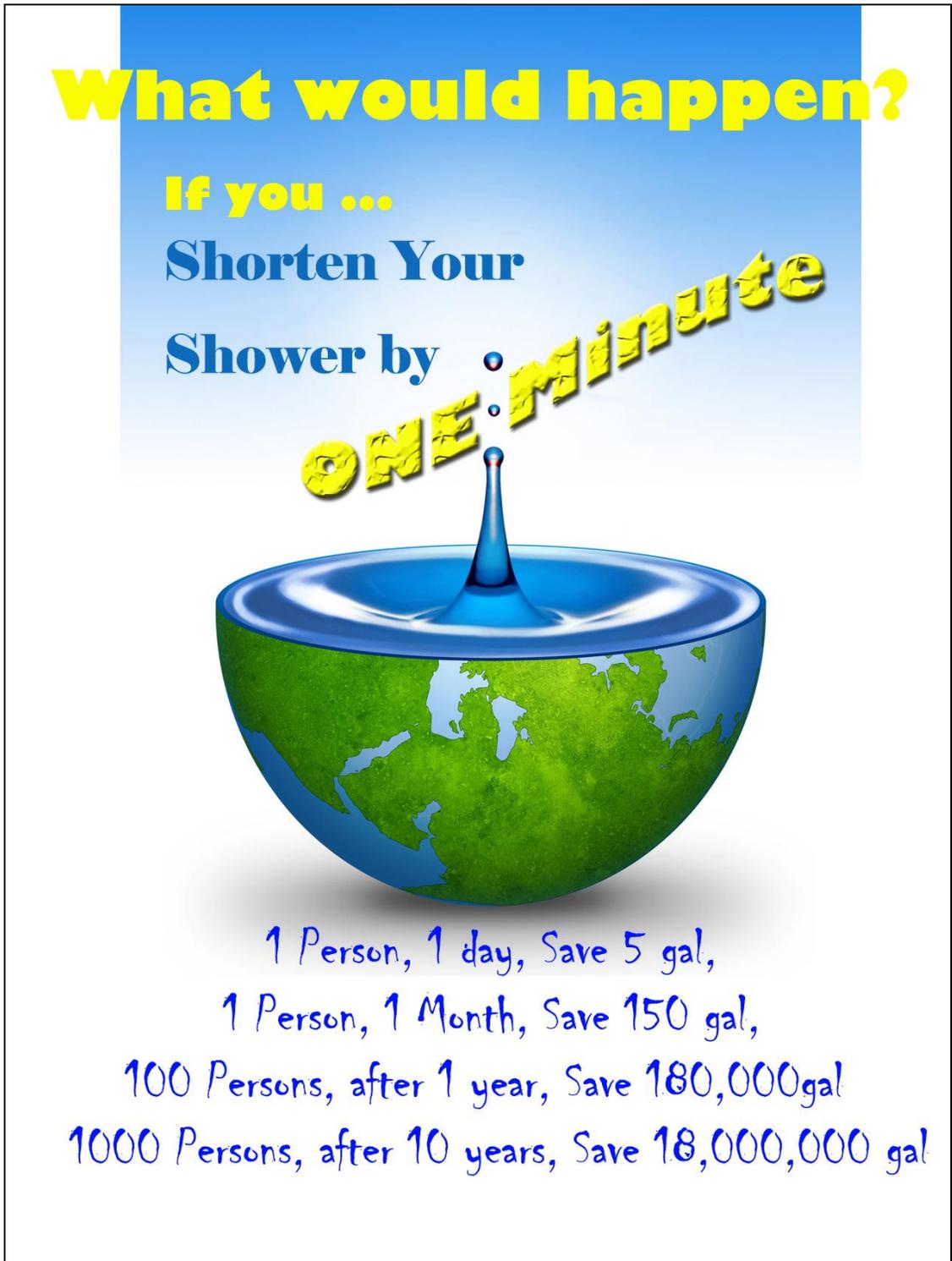


Figure 15: "Just One Minute" Campaign Poster

Appendix II: UMD Domestic Water Map

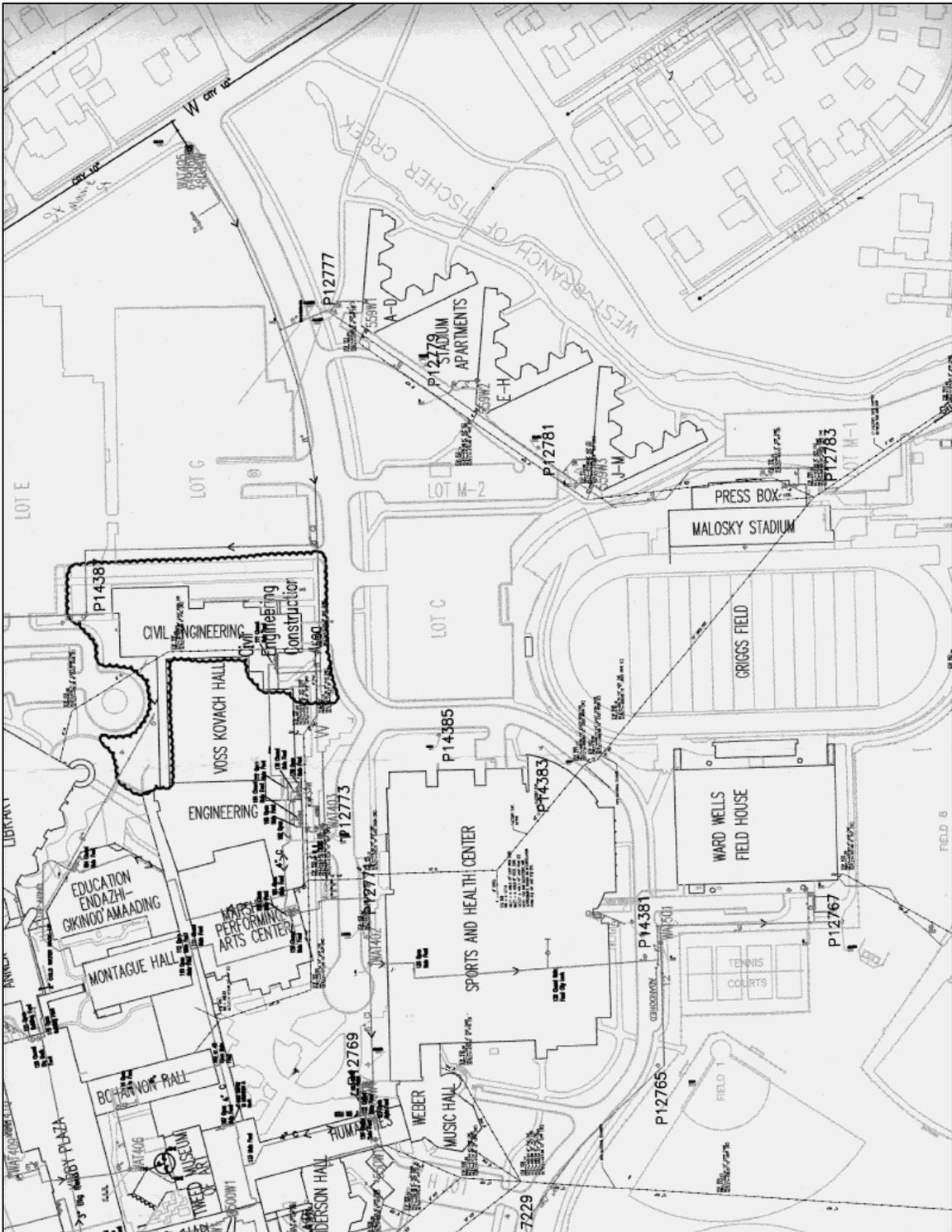


Figure 16: UMD Domestic Water Map (UMD Facilities Management, 2009).

Appendix III: City of Duluth Water System Layout

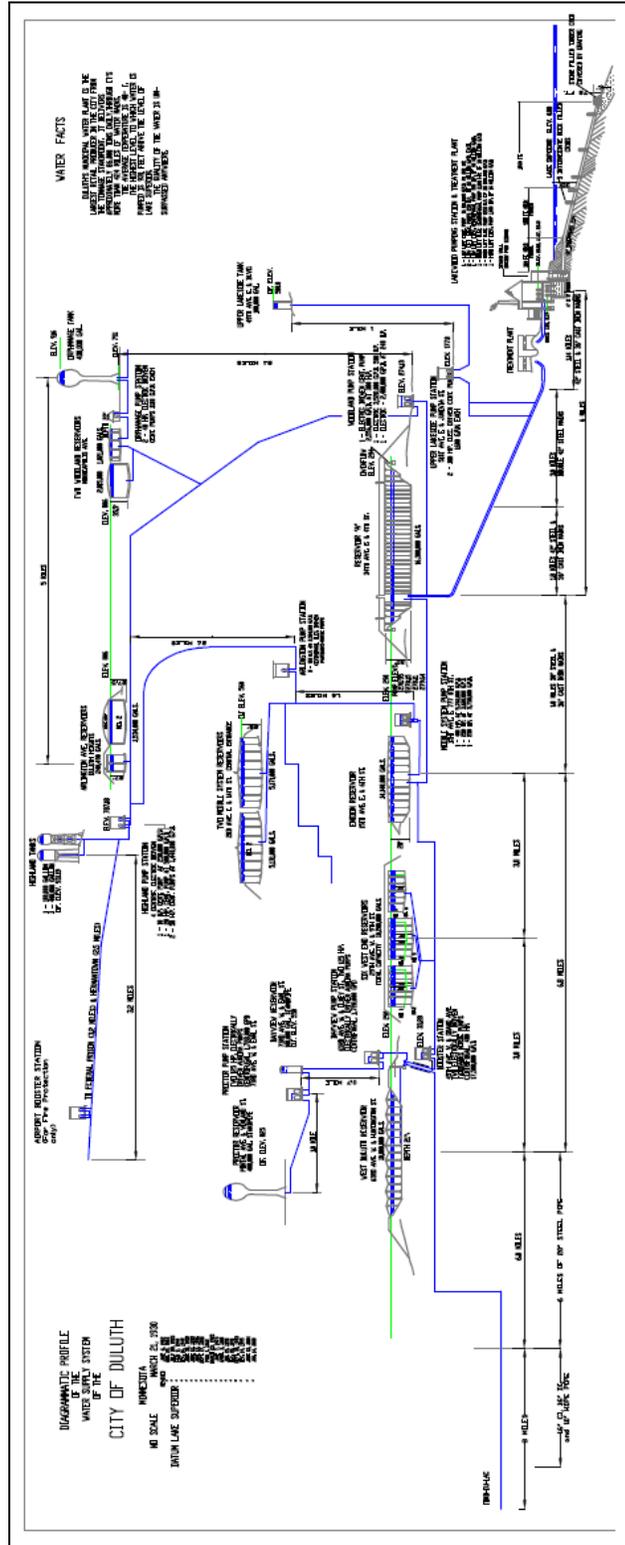


Figure 17: City of Duluth Water Supply Map (City of Duluth, Comfort Systems, 1930).

Appendix IV: Constituents

Constituents to be invited to the final presentation of our research team's findings of water consumption in SpHC are listed below. Nearly all of these individuals are already aware of the research project and will be invited to the presentation on April 30, 2010, via a formal invitation. Those individuals not already aware of the presentation may be contacted in the near future for interviews related to data collection and recommendations.

Constituents:

Gregg Batinich- Aquatics Director Recreation Outdoor Sports Program
Mindy Granly- Sustainability Coordinator UMD Facilities Management
Howard Jacobson- Operations Manager Gas & Water Supply Department of
Public Works & Utilities
John King- Director UMD Facilities Management
Erik Larson- Engineer Facilities Management
Mark Nierngarten- Department Head UMD Health, Phys Ed/Rec
John Sawyer- Principal Engineer Supervisor UMD Facilities Management
Chris Stevens- Recreation Facilities Manager
Roger Worthing- Mechanic 2, Facilities Management

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