Development of a Business Model for Incorporating Water Conservation Practices in Academic Facilities

ME 589: Sustainable Design of Technology Systems
Final Report for the Fall Term of 2013

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Abstract

A business model was developed to provide the initial financing for installation of water conservation technologies at academic facilities, located in regions where water prices are currently high and forecast to increase greatly in the coming years. Schools will be able to pay back the cost of the installation over a 5-year time period, at a rate equivalent to 80 percent of their savings for each of the five years.. The motivation is to provide schools with substantial savings so that they may re-allocate funds within their diminishing budgets to provide more services directly to students.

Executive Summary

Our team created the foundation for a business that provides the capital and installation of water conservation technology in schools. The investment is paid back and profit is generated by collecting 80 percent of the schools' annual water savings post-retrofitting for a period of five years. The business model will rely on investors to generate the initial funding in addition to small loans.

This sustainable business concept was generated after looking into developing new water conservation technology for the home - a water-repurposing system that uses second-hand potable water for non-potable uses - and discovering that similar technologies currently exist but are minimally implemented. The reason for this lack of water conservation technology usage can be attributed to the expense and lack of consumer knowledge about available products. Consequently, we attempted to provide an uncomplicated way for consumers to connect with, and invest in, existing technology that is also financially lucrative. We chose to target schools rather than homeowners because a schools' water usage is extremely high compared to a residential unit, which decreases the payback period of water technology installations. Additionally, schools are likely to be interested in our service because they are constantly facing local, state, and federal budget cuts and can benefit from reducing operational costs. However, due to the tight budgets, schools rarely have the money to invest in building projects, which is what makes our service appealing. Environmentally, our main objective is to conserve water as the available freshwater we currently have access to on Earth is being consumed at an unsustainable rate. Socially, we plan to incorporate an educational component to compliment the installation of water technology hoping that students will continue the dialogue at home with their parents and into their adulthood.

We plan to start our business in Atlanta, Georgia because it has the most expensive water in the United States: $30 per thousand gallons. Eventually, we plan to branch out to other regions of the United States where water is expensive. Our service developed in this report focuses primarily on the reduction of restroom water consumption and has the ability to reduce restroom water use by 70 percent (in, which amounts to an annual savings of approximately $45,000 in Atlanta, Georgia. As our business takes off and we have more time and money to invest in research and technologies, other end-use areas of water consumption at schools can be explored for reduction, such as, landscaping, irrigation and kitchens.

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1 Introduction

Energy used to be at the focus of most resource debates. However, the accessibility of water has cast energy to the darkness and taken the limelight. At present, municipalities are struggling to keep up with the incoming volumes of wastewater, and due to overflow, large amounts of untreated water are being dumped into blue water sources. In an initial needs-finding exploration, our team looked at repurposing home water as a means to reduce consumption by developing a grey water system to provide potable water. However, the persona we focused on is a small niche; and therefore, our idea would not have a profound, transformative effect on society, which is an end-goal of sustainable design. Consequently, we expanded our thought process to find a more dire need related to water conservation.

First, we explored where water is most expensive and increasing in price rapidly. Then, we looked at the end-uses of water across various facilities and discovered that schools are using nearly 75 percent of their water on domestic/restroom and landscaping as shown below in Figure 1-1 [1].Ultimately, we developed the idea of generating a business model that installs water conservation technologies in schools located in areas where the price of water is exceptionally expensive. The schools do not pay any up-front costs, but instead pay a percentage of their water savings over a calculated time period until the technology is paid off and our business generates a sustainable profit.

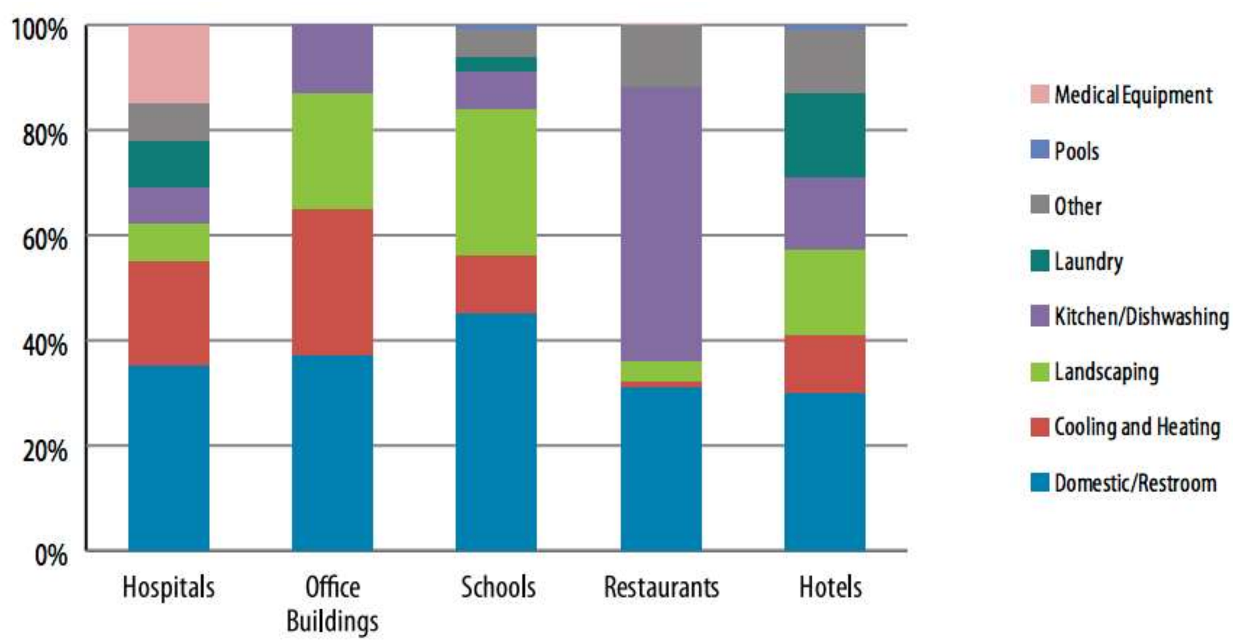

FIGURE 1-1 END USES OF WATER IN COMMERCIAL AND INDUSTRIAL FACILITIES [1]

Environmentally, this project aims to conserve water in areas that are facing high water prices due to the rising cost of treatment and/or blue water shortages. Socially, schools are facing massive budget cuts, which affect their ability to provide students with adequate services. For example, a public school in Michigan had to lay-off ten faculty members within the last five years. The principal at this school acknowledges that operation costs are less than 10 percent of their expenses, but followed this by saying that "...every $1000 - or heck - every $100 counts when it comes to providing a quality education." (For the full interview, please see Appendix A). Our business model would provide schools a way to cut down their utility costs so that they may allocate money elsewhere, without requiring schools to supply a large amount of capital investment up front. This is a lucrative plan to schools, as there are currently many water conservation technologies on the market, but they are relatively expensive to install. At present, there is no existing business that provides the service we are attempting to develop; however, there are businesses that do what we are attempting to achieve in the arena of solar panels. Therefore, we will be investigating these companies to understand how they got started and delve into faults to ensure that our business will be as successful as possible. We will also need to develop an economic model of the school's payment plan and how much capital we will need from investors to get our business started.

As our team intends to be the middleman in water conservation installations, we must consider the school board, who will ultimately hire us, and consequently, how school budgets are proposed and implemented. Additionally, we will have to look into contractors and decide if we will have a contractor on our payroll or hire out contractors located within the school district we are servicing. Ultimately the stakeholder that will see the largest benefit from our business model are schools, which will be ultimately saving money for no up-front investment..

2 Functional Status

Water conservation technology is not a new concept. In fact, evidence shows that Raja Raja Cholan systematically implemented rainwater harvesting for farming and water collection as early as 1,000 C.E. in India [2]. Today the Islands of Bermuda mandate adequate water collection in all new residential building sites [3] and BLUElab at the University of Michigan has embarked on water collection and conservation activities in areas such as Nicaragua and Jamaica where water is scarce and unsanitary. The Middle East and North Africa (MENA), the most water-scarce regions in the world, also incorporate many water management and conservation efforts to maintain water accessibility to their populations. Such activities used by MENA to manage water scarcity and human demand include: increasing supply, which is costly and becoming more difficult as there are fewer untapped fresh water sources than ever before; Qanats, or chain wells, which collects water from mountainous areas by boring horizontal tunnels into them and collecting the water in an oasis or other water drain out in arid regions; rainwater harvesting from roofs, cisterns, and other sources and diverting the water to ponds, reservoirs, wadis (dry riverbeds that become ponds after heavy rains) and earthen dikes; sequential water use; desalination, which is extremely energy intensive; using less water-intensive crops; and investing in efficient technologies. An example of the latter is the incorporation of drip irrigation, which can cut water use by 30 to 70 percent and increase crop yields by 20 to 90 percent, compared to traditional irrigation methods [4].

This research shows that many areas, particularly those that are experiencing water scarcity, are incorporating water conservation and collection practices. Though generally, developed regions with access to fresh water, are less likely to conserve unless there is some kind of monetary incentive. This is evident when comparing the water footprint of the Americas to the rest of the world as shown in Figure 2-1. And though we see water-harvesting practices spreading through the rest of the world, some states in the U.S.A., such as Colorado, only recently passed laws allowing water collection. It is evident that conservation practices vary by region and country; though droughts, water-supply shortages, and the growing cost of water is pressing us to become more water conscious.

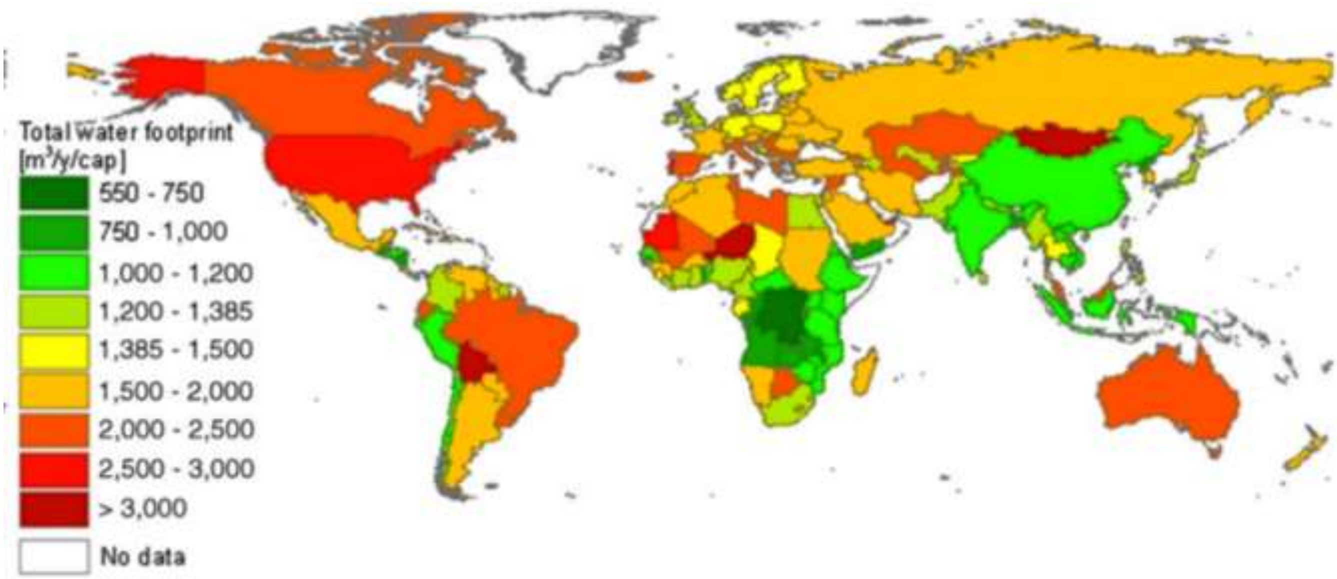

FIGURE 2-1: WATER FOOTPRINT OF CONSUMPTION PER COUNTRY IN THE PERIOD 1996-2005 (M3/YR PER CAPITA) [WATERFOOTPRINT.ORG]

There are many other technologies that have proven to be successful at reducing water consumption in both residential and commercial settings resulting in significant water utility cost reductions. The Federal Energy Management Program offers 14 Best Management Practices (BMPs, shown below) that address *'all of the various uses and maximize conservation'* [1].The Environmental Protection Agency (EPA) commonly uses these BMPs in their facilities to minimize water use and maximize water efficiency [5] resulting in a 18.7 percent reduction water use from 2007 (35 gallons per gross square foot, GSF) to 2010 (28.5 gallons per GSF) and as much as 60 percent, a reduction of more than 2.1 million gallons per year, at the National Exposure Research Laboratory, Office of Research and Development (ORD) in Athens, Georgia [5]. The following is a list of the 14 BPMs outlined by the Federal Energy Management Program and discusses consumption norms and standards as outlined in *WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities* [1].

1. Water Management Planning – According to the EPA this should be the first step to establishing water conservation techniques and sustaining long-term water savings. Four areas are addressed in the planning practice:
    a. Reducing water loss (e.g., leaks) – Increasing the water efficiency of fixtures, equipment, systems, and processes by retrofitting existing components or installing new water efficient items (addressed below)
    b. Educate occupants about water efficiency and encouraging conservation
    c. Reusing onsite alternative water that would otherwise be discharged to the sewer (e.g., reusing treated gray water or rainwater)
2. Information and Education Programs – Sharing management's commitment to water efficiency, graphing monthly water use, and informing users of proper operation tend to show improved savings compared to simply installing new water efficient components.
3. Distribution System Audits, Leak Detection and Repair - This includes metering and sub-metering, comparing the results on at least a monthly basis and analyzing the results to identify possible leaks.
4. Water-Efficient Landscaping – In general, landscaping plants should be converted from those with high water requirements to lower requirements and should have a high composition of native vegetation and soils. There are many other items that should be evaluated, which must be done on a case-by-case basis, though studies have shown savings from 18 to 50 percent. Costs

for retrofitting or replacing can be costly; though the goal should be to optimize water use and minimize runoff, allowing moisture to be maintained in the soil for longer periods of time.

5. Water-Efficient Irrigation – Water conservation in irrigation can be achieve by way of:
   a. Installing drip irrigation to water trees, shrubs, or plant uses 50 percent less water than conventional sprinklers. The systems require little more than a connection to a hose or outdoor faucet, tubing to transport the water, ground stakes, tubing connectors and emitters. A system to drip irrigate 23 plants can be acquired for as little as $30 minus the tubing and faucet connector.
   b. Replacing sprinkler heads can reduce water use by 30 percent with prices ranging general from $2 to $10, though this depends on the application.
   c. Installing smart controllers offer savings of 10 to 20 percent over traditional manual or clock based controllers by incorporating weather data or onsite conditions. The costs for a controller and installation have base cost from $2,500 to $6,000; though additional cost should be expected.

Outdoor Water Use Case Study: In 2009, the Granite Park office complex in Plano, Texas completed an irrigation audit, installed a WaterSense labeled weather-based irrigation controller, rain sensor, and freeze sensor, and performend needed maintenance to the existing irrigation system yielding a savings of $47,000 and 12.5 million gallons of water in 2009 with a simple payback of less than 1.5 years.

6. Toilets and Urinals – Toilets and urinals are by far the largest domestic/restroom water consumers. Toilets pre-dating the Energy Policy Act (EPAct) of 1992 typically used 3.5 to 5 gallons per flush (gpf) and urinals used between 1.5 and 3.5 gpf, while current standards are set a 1.6 gpf and 1 gpf, respectively. Additionally, WaterSense certified replacements could provide additional savings as current replacement options use as little as 1.1 gpf and 0.125 gpf, resulting in savings between 20 to 74 percent and 87 to 96 percent for toilets and urinals, respectively. The costs of these technologies range from $250 to $700. Additional options include replacing single-option flush valves with dual flush valves if the existing toilet is compatible and using water free urinals, each of which can lower water to a greater extent.
7. Faucets and Showerheads – Faucets and showerheads retrofits offer substantial saving for perhaps the lowest cost. Due to the EPA Act of 1992, faucet consumption was regulated to no more than 0.25 gallons per cycle (gpc) and the American Society of Mechanical Engineers

(ASME) A112.18.1 specified maximum flow rates of 0.5 gmp at 60 psi - though the latter is not a federal regulation. Many public faucets today still have higher flow rates between 2.0 and 2.5 gpm. Faucets in poor working order should be replaced to meet today standards; however, retrofit options such as aerators can be acquired for as little as $4, the installation requires no cost, and a 75 percent water savings can be achieved. Efficient showerheads can also be acquired for as little as $15, installed at no cost, and offer at least 40 percent savings over the EPAct of 1992 standard of 2.5 gpm.

Domestic/Restroom Case Study: In 2007, a hotel in San Antonio, Texas replaced its toilets, showerheads and installed high-efficiency aerators in all 397 guest rooms. The installation cost roughly $100,000 and yielded savings of over $68,000 in water, sewer, and energy cost annually yielding a simple payback in less than two years.

8. Boiler/Steam Systems – Boiler and steam systems are used in large buildings for heating and water heating, such as hot water boilers that provide hot water facility activities (e.g., showering, cooking, washing dishes and laundry, etc.). Though water efficiency is not a primary concern hot water boiler systems and replacement involves significant capital cost, efficient operations should first be conducted. Replacement needs can be validated through energy audits
9. Single-Pass Cooling Systems – Single-pass systems use water to remove heat and cool equipment such as chillers, condensers, compressor, lab equipment, ice machines and wok stoves. The specific retrofit and replacement options will be considered where needed noting that savings can also be achieved in the energy sector for these applications.
10. Cooling Tower Systems – Cooling towers are used to remove excess heat in facilities such as schools, office complexes and hospitals. For example, 11 percent of a schools' water budget is attributed to heating and cooling. To increase water efficiency operation, maintenance, and user education should be addressed first and retrofit options including: metering; controls systems; components to improve water quality; etc., should be considered later.
11. Commercial Kitchen Equipment – Though water use in school kitchens will vary greatly depending on the occupants, population, and services provided, its end used is contributed to seven percent spread over various components including: ice machines; combination ovens; steam cookers; steam kettles; wok stoves; dipper wells; pre-rinse spray valves; food disposals; commercial dishwashers; and wash-down sprayers. Though each site will need to be evaluated

for kitchen water savings depending the equipment installed, two low cost conservation practices include replacing pre-rinse spray valves with more eco-efficient items for less than $100 providing up 85 percent savings and reducing water use for food disposal (one example is composting).

12. Laboratory/Medical Equipment – This category will be addressed as needed and is not expected to be a large area of consumption for most schools.
13. Other Water Use – Additional High-water using processes should be inventoried and operational characteristics analyzed to determine if any efficiency improvements could be made on a facility-by-facility basis.
14. Alternate Water Sources - Alternative water sources potentially include municipally supplied reclaimed water and treated gray water from on-site sanitary sources, rooftop rainwater recovery system captures, rain barrels and cisterns. Alternate water sources such as cisterns and rooftop rainwater recovery systems have great potential to reduce both demand and downstream impact on treatment facilities, though they may require greater capital cost than other conservation practices

Rainwater Harvesting Case Study: At the Science and Technology Center in Kansas City, Kansas, a unique rooftop rainwater recovery system captures and filters rainwater for use in wastewater fixtures, reducing the need for treated domestic water by approximately 50 percent and reducing site runoff by 40 percent. An estimated 735,000 gallons of water are saved by this unique system. The excess water collected by the rainwater recovery system is used to provide make-up water for the building's cooling towers [5].

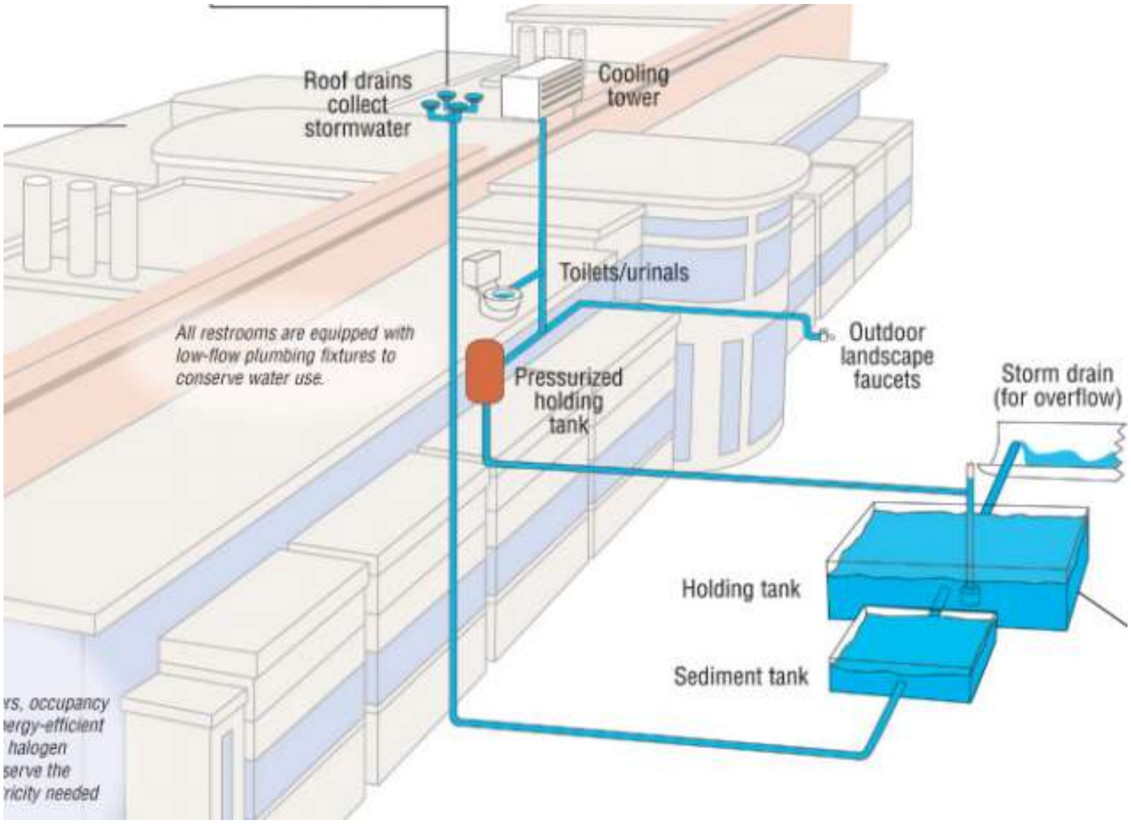

FIGURE 2-2: KANSAS CITY SCIENCE AND TECHNOLOGY CENTER, RAIN WATER RECAPTURE SYSTEM [5]

These technologies and BMPs offer significant savings and can have notable impact on the sustainability of fresh water use. Some of the BMPs offer reasonably priced options for both residential and commercial facilities, while others may offer greater efficiency and reduce consumption at a higher capital cost. Additionally, the success and cost of some BMPs such as water management plans and educational programs are difficult to evaluate. Choosing which technologies and practices to employ is site specific and must be carefully evaluated on a case-by-case basis. This information will need to be carefully considered throughout the ethnographic study, primarily targeting system and technology experts.

3 Design Ethnography

This section provides our approach to gathering pertinent information for our design process.

3.1 Frame the Guiding Questions

1. Given that we know water conservation technology, rainwater capturing, and gray water repurposing system currently exist in the market, why are these technologies not more widely used?
2. What current gaps in technology exist that discourage more widespread use of these systems?
3. What are the requirements for installing and using these systems, including relevant policies?
4. Are consumers knowledgeable enough about their personal water use, or would we have to educate them on the benefits of these systems?
5. Is water a significant enough of a cost to motivate consumers to change their behaviors and look for ways to save, similar to the energy use and energy efficiency systems?
6. Who are the users that are most likely to benefit from this system?
7. What are the costs involved in purchasing, installing, and maintaining these systems?
8. What will make this a financially viable project?
9. What are the labor requirements for installation?
10. What are the system or infrastructure requirements for the building or properties that may exclude some schools as candidates?

3.2 Define the "Who"

1. Users:
   a. Public schools interested in lowering their water costs.
   b. We decided to target schools instead of consumers or businesses because we believe that schools:
      i. Are not savvy about their water use
      ii. Would like to reduce their water expenses, but lack the capital to invest in a sustainable system
      iii. Would appreciate the educational opportunities a rainwater collection system would allow to the students
         i. In addition we are targeting users in areas that have high water costs and areas have a high annual precipitation. Based on our research, we have identified the areas with the highest water costs, including: Sante Fe, Seattle, Atlanta, Baltimore, Boston, San Diego and Los Angeles [6].

ii. Additionally, water costs have been increasing dramatically nationwide but most noticeably in: Atlanta (+233%), San Francisco (+211%), Wilmington, DE (+200%), Philadelphia (+164%), and Portland (+161%) [7].Users in these areas would likely be the most receptive to systems that provide cost savings.

iii. Our ideal user would be a public school that is facing budget constraints and is looking to cut costs while providing educational opportunities for students around sustainability. Our user will be knowledgeable about water conservation issues, sensitive to environmental concerns, and receptive to increasing environmental efficiency in schools.

2. Stakeholders
    a. Public School administration
    b. Public School students, teachers, and other faculty and staff
    c. Parents of students
    d. Taxpayers in the areas we are targeting
    e. Wastewater treatment plants
    f. Water utilities
    g. Manufacturers and contractors of water conservation technologies
    h. Investors
3. Experts:
    a. Manufacturers and designers of rainwater collecting systems, gray water repurposing systems, and water conservation technology
    b. Wastewater treatment plants
    c. School officials
    d. Construction crews that will install the systems
    e. Solar financing companies (ex – Solar City)
4. Clients: The main client will be the school administrations. We will provide them with the knowledge, technology, and capital required installing these systems. However, we will also connect the schools to the manufacturers and contractors of the wastewater and rain water repurposing systems, so that group can also been seen as a client.

3.3 Synthesize Existing Knowledge

1. There are a number of water conservation technologies currently on the market, such as wastewater repurposing systems, rainwater collection systems, and domestic/restroom water reducing components (Low flow faucets and showerheads, low flush toilets, etc.); however, there is notable room for additional installations to yield significant water and cost savings [8].

Fixture/Appliance	Warehouses	Retail	Food Sales	Fast Food	Restaurants	Offices
Ultra-Low Flush Toilet	31.8	45.4	47.2	68	44.1	49.8
Low-Flow Urinals	21.6	5.9	24	22.2	22.7	24.4
Faucet Aerators	72.2	65.9	60.8	60.1	57.5	78.3

TABLE 3-1: MARKET PENETRATION OF WATER-CONSERVING FIXTURES IN NON-RESIDENTIAL SECTORS (PERCENTAGE)

2. Storm water runoff in urban and developing areas is one of the leading causes of water pollution in the US, so there is a huge opportunity from a pollution and conservation perspective [9]. According to the American Water Works Association (AWWA) Research Foundation, homes with access to alternative sources of irrigation such as gray water, reclaimed water, and collected rainwater reduce their water bills by as much as 25 percent [10].
3. Schools consume water for landscaping/irrigation, domestic/restroom, cooling/heating, and kitchen/dishwashing uses.
4. Most public schools cannot afford the capital investment in water conservation and repurposing systems, despite the lucrative cost savings that these systems may provide over a number of years.
5. Schools are constrained by budgets.

3.4 Data Collection Methods

We will collect data from the various users, stakeholders, experts, and clients initially through research and observations, and conduct a series of interviews at various points in the project to gain knowledge that we cannot otherwise collect.

1. Public school administration:
    a. The goal of our data collection is to understand current water use and motivations for investments in water conservation technologies specifically for schools.
    b. Research water costs for different regional areas, the average water expense of schools in different areas, and increasing costs of water use
    c. Observe current water use patterns to understand how these schools currently use water
    d. Observe current energy efficiency programs in the schools to understand if sustainability is an area that the schools have historically invested in
    e. Research school budget allocations for utilities
    f. Research who is responsible for cost control within the school, and what his or her incentives are to reduce costs
    g. Interviews will be the main source of data for this group. From interviews, we can understand:
        i. How much knowledge the decision makers within the schools have about water use
        ii. How the school views its water use
        iii. Criteria for investment in capital projects
        iv. The school's interest in new projects
    h. Interview schools that have already adopted water conservation or energy efficiency technologies to understand the motivations and requirements, find lessons learned, understand how much actual cost savings they realized and if the cost savings met their expectations, and understand best practices to try to avoid some of the pitfalls and struggles that they may have faced (See Appendix A for preliminary interview with a high school principal).
2. Manufacturers and designers of water conservation technologies
    a. Research to understand the current technologies available and the costs associated with the purchase, installation, and maintenance of each technology
    b. Research current adoption and profiles of customers to understand who these systems currently appeal to
    c. Research locations that have the highest adoption rates of these systems to understand the main drivers behind adoption (local cultural tendencies towards sustainability, high water rates, favorable government policies, etc.)

d. Observe the requirements for installation and costs behind these systems and any variation on cost between different manufacturers
e. Interview manufacturers to understand their major customers, materials used in the process, and drivers of cost of systems
f. Interview designers to understand the main features of these systems and how they work
g. Interview contractors to understand what is involved in installation, including cost, manpower, interruptions on the property caused by installation, time required for installation, and how much the existing property needs to change to implement these systems (See interview transcript with construction guru, Appendix A).

3. Construction Crews Involved in Installation of Water Conservation Systems
   a. Conduct interviews to understand the time, materials, cost and labor requirements behind installation of the various different technologies.
   b. Research differences in construction costs based on different locations
   c. Research any permit or bylaws that may impede construction of water conservation systems at schools
4. School Maintenance (Groundskeeper, Janitors)
   a. Conduct interview to understand current use and requirements for water
      i. Amount of sprinkler use and use rates for different times of day and year
      ii. Amount of traffic in bathrooms, kitchens, showers, etc.
      iii. Any problems with the existing system and age of system
   b. Research tasks involved in the new systems we are planning to install to determine the maintenance requirements and potential costs
5. Wastewater Treatment Plants
   a. Research cost structures and opportunities for savings already in place
   b. Observe operations to understand current problems and limitations in water treatment
   c. Research current options for water repurposing for customers offered by the wastewater treatment plants
   d. Interview officials at plants to understand the limitations around repurposing water, the current problems faced by wastewater treatment plants

6. Public School Students: We want to link the benefits of the water conservation systems to the potential for educational opportunities for students, as an additional benefit of adopting these systems.
    a. Interview students to understand their current knowledge of water conservation issues
    b. Research student organizations and programs that support sustainability initiatives and conservation issues
7. Public School Teachers, Faculty, and Staff: Interview teachers, faculty, and staff about efficiency and conservation programs in target schools, what knowledge about water conservation exists, and understand the underlying support for a water conservation program
8. Taxpayers
    a. Conduct interviews to gain insight into the level of community support and willingness to pay for a water conservation program in schools
    b. Research current tax levels and how they compare to surrounding districts

3.5 Data Collection Structure

We will collect the data by conducting research, observing users and stakeholders in our target area, and interviewing users and stakeholders. We will research the systems involved in water conservation, such as gray water repurposing systems, rain water collection systems, and water efficient installations and retrofits to understand the costs associated with the purchase, installation, and maintenance of these systems.

We will conduct the majority of our interviews by phone or Skype, as our target areas are too far to travel to. We can observe schools in the Ann Arbor, Detroit, and Lansing areas and interview school officials, faculty, staff, and students from those areas as well, to get a general understanding of school structures, while supplementing our knowledge gathered in these areas with interviews and research in our target market areas.

When we visit the schools, we will use the observations framework to guide our observations and structure our visits. Most of our understanding of this space will be based on interviews and research; however, when we visit schools we can use the observation framework to understand current water use.

- A – Actions: Compile areas where water is currently being used in schools. Currently, we believe these areas include sprinklers, toilets, sinks, kitchen use, drinking fountains, and science classrooms. We will observe how and how much water is being used in these areas and if there are any other areas.
- E – Environments: bathrooms, hallways with drinking fountains, kitchens, lawns, and science classrooms.
- I – Interactions: Who makes the decisions for water use on lawns, and how is this communicated to the maintenance staff? What interactions take place between decision makers and water users?
- O – Objects: What objects are involved in the water system in the school? Are any pre-programmed? How are these objects monitored?
- U – Users: Users include maintenance staff, kitchen staff, students, faculty, and other staff, and any visitors to the school. We will observe which groups of users have the most impact on water use and their behaviors around water use.

3.6 Interview Structure for School Administrator

Below is a template of the questions we will ask the administrators to understand their mindset and knowledge of water conservation and understand the likelihood of adoption of these technologies.

1. Introduction
   a. Introduce myself and my teammates
   b. Describe our project and the information we are looking to gather in the interview.
2. Kickoff
   a. What is your role in the school district?
   b. What would a typical week working in your role consist of?
3. Build Rapport
   a. What are the biggest concerns currently facing your district?
   b. How do you view sustainability
4. Grand Tour

a. What are some of the budget and cost issues facing your district?
b. How does budget impact investing decisions?
c. Is there a certain rate of return that new school cost savings programs must attain?
d. What are some of the energy efficiency initiatives that your schools district is currently pursuing?
e. What do you know about water use in your school district?

5. Reflection
    a. Summarize understandings about budget concerns and investment decisions for the school district.
    b. Link personal views on sustainability to energy efficiency initiatives in schools.
6. Wrap-up
    a. Thank you for your time. Are there any other thoughts about budgets, water conservation, energy efficiency, or any other information that you want to bring up?

We conducted an interview with Jeff Carlson and Cheryl Pedisich of the Three Village Central School District on Long Island, New York. The Three Village School District is in the design stage of an energy services contract with Johnson controls, which includes replacing old, inefficient boilers and burners and replacing old lighting fixtures with more energy efficient LED fixtures. For this project, the energy savings over a period of approximately 18 years will pay for these installations. The energy efficiency project with Johnson Controls coupled energy efficiency improvements with hands on learning opportunities for students, which is similar to activities our business intends to pursue.

We learned from Jeff and Cheryl some of the steps involved in approving capital projects in New York schools. Each year, the Business finance committee presents the budget to the school board, including how much in utilities that they will need for the year. When they are considering capital projects, they must present to the facilities committee of the board.

One of the main challenges that the school faces is coming up with the upfront capital to do any projects in the school buildings. There are many state programs to provide building aid; however, the construction project must be completed before the state will provide aid for many programs. NYS Department also has certain requirements for the capital project to qualify as an energy performance contract; the school district must ensure that the project complies with the standards or they will not receive funding. They also face school budget and cost issues when financing renovations or infrastructure improvements. There is a tax cap in New York State; lawmakers are prohibited from increasing taxes by more than 2 percent or the Consumer Price Index, whichever is lower. It is difficult to find funds in the budget for capital projects when schools have contractual salary increase, health insurance costs, retirement benefits, and have been cutting staff.

When choosing companies to perform capital projects in Three Village school district, Request for proposals, the school must first advertise the work to be done, and solicit bids from interested companies, allowing the companies to do a walk-through of school. If a company were to pitch a capital project, Jeff would meet with them to hear the ideas. Then he would ask other experts in the area about the project (for example, the state education department – office of facilities planning) and talk to superintendent, before presenting the idea to the Board of Education facilities committee. The facilities committee would then present the idea to the full Board. Depending on type of work, the project might need voter approval to proceed, or may have to wait to be worked into following year's school budget. The entire process could take anywhere from two months to a year, as shown by historical project timelines.

A transcript of this interview can be found in Appendix A, which also includes interviews with other school administrators, as well as, technology and subject matter experts.

4 Sustainability Evaluation

To evaluate the sustainability of our design, we will be using the method outlined in "Environmental improvement through product development - a guide," which was created by the Technical University of Denmark [11]. While the seven steps of sustainability are directed at the development of an object/prototype, the guidelines can still be applied to a service. Thus far, we have attempted to fit aspects of our service development into the first four steps.

4.1 Use Context

Our service will provide clients with the installation of water conservation technologies without requiring them to provide the up-front capital costs. We will be marketing our service to educational facilities that are located in regions where the price of water is expensive and expected to increase at the current rate or higher over the next ten years. The length of our service is two-fold. The first time frame includes the consultation with the educational facility and the installation of the water conservation technology. The second time frame involves the period where we collect a fraction of the facility's savings from decreased water use to pay-off our investment and generate a profit.

With these two time-frames, there are two different environmental impacts to analyze. The first time frame, which coincides with the retrofitting of the building, includes the disposal of the existing water technologies, the raw materials and manufacturing of the new technology, and the energy used in construction. The second time frame involves the environmental impact of the usage and disposal of the upgraded technology, as well as, the overall water savings relative to an appropriate baseline.

4.2 Environmental Overview

Our overall goal is to reduce water consumption, which in turn reduces utility bills. This seems like a wholly positive venture; however, as we are installing new technology into an already existing buildings. Consequently, we must consider the environmental impact of the energy used in the technology production, the installation, and the demolition associated with retrofitting. We believe that if the embodied greenhouse gas emissions in the water being saved are larger than the emissions from the production, installation, and disposal of the technology, we are truly being sustainable and cannot be accused of "green-washing." Essentially, we want to be sure that our business will not be creating a bigger problem than what we are trying to solve.

4.3 Environmental Profile and Root Causes

Schools in the United States are relatively large consumers of water at present due to the fact that education is viewed as a right in the Americas and the best chance at having a successful life. This leads to a majority of children in the United States attending school for 12 years in order to obtain a primary education. School buildings used to be relatively small, sometimes the size of a moderate house. However, with the increasing population, and thus, an increase in pupils - as school is the expected path in life - the size and services of schools increased out of necessity. As students spend 7-8 hours in school every day for roughly 40 weeks each year, bathrooms and lunch must be provided to ensure the basic needs of the students are met. Both bathrooms and kitchens have water technology present, but bathrooms account for more than 50 percent of total water use in schools [1].

The environmental impact of our business model will be primarily evaluated by analyzing reduced water consumption. Water is consumed at a particularly unsustainable rate. This over-consumption stems from the amount of fresh water availability the U.S.A., but more importantly from a lack of water awareness and a broken system, in which water utilities are cheapened. Over-consumption must be addressed to insure our water security and sustainability moving forward. Secondarily, we will investigate the greenhouse gas (GHG) emissions from energy used in the production, installation, disposal, and use phases of the water conservation technology we will be installing to ensure we are not creating a larger problem than the one we are attempting to solve.

Looking at the technology production phase (raw materials and manufacturing), we realize that there may be other environmental impacts, such as the use of harmful chemicals that may affect the biosphere more than the GHG emissions from energy use. However, if the embodied GHGs are not an issue, it is highly likely that other aspects of production, such as, hazardous chemicals are not an issue either.

The installation of the technology may require electric tools such as drills and saws. Instead of looking at the emissions from the manufacturing of the power tools used, we will be looking strictly at the emissions associated with the use phase of the tools. This decision is based on the assumption that the contractors performing the installation already own the necessary equipment and do not need to buy new tools. Consequently, the emissions from the manufacturing of the tools will be considered as "sunk emissions" - similar to sunk costs - and will not be included in the sustainability evaluation. The water used before and after retrofitting will be evaluated for the total GHG emissions produced from the energy consumed during supply and treatment the water.

The last area of concern to look at for overall, environmental impact is the GHG emissions associated from the end-of-life disposal of the technology removed during retrofitting.

4.4 Stakeholder Network

A visual diagram of our service's stakeholders is provided in Appendix B. The stakeholder network web is a depiction of a school's water consumption and the decision-making process involved in implementing water conservation technology. The red stars denote the impact areas of our service design.

4.5 Quantification

When analyzing the GHG emissions associated with the baseline and our alpha design, we will include the energy associated with the use phase of electric tools used in the installation for this report. However, obtaining actual values of the energy used is difficult to determine. Therefore, we will estimate that the electricity used for installation is equivalent to ten percent of the GHG emissions associated with the production and manufacturing of each technology to be installed. Most raw materials, manufacturing, and end-of-life disposal data was taken from literature [12]. However, this article lacked the production and disposal emissions associated with urinals and sink faucets. To obtain an estimate of GHG emissions associated with urinal production and disposal, we thought it was appropriate to multiply the emissions associated with the production and disposal of a toilet by the ratio of urinal mass to toilet mass, or (42 lbs/65.5 lb), because both are made from the same ceramic material. Masses of fixtures were based on shipping weight from a leading manufacturer [13]. Using the same production and disposal emissions for showerheads circumvented the lack of emissions data for faucets, as both fixtures are made from similar materials and perform similar functions. Energy consumption from the supply and treatment of water during the use phase are 1,100 kWh/million (MM) gal and 2,500kWh/MM gal, respectively [14]. The emissions factor used in calculating GHG emissions is 0.188 metric tons (mt) carbon dioxide equivalent (CO2 e-) per GJ and includes the impact from carbon dioxide, methane, and nitrous oxide [12].

Water usage reduction is also considered and presented in the sections titled Environmental and Social Impacts of the Baseline and Improvements of the Alpha Design over the Baseline.

4.6 Conceptualization

There are various ways to reduce the environmental impact of the baseline. The concept generation we explore in this report is present in a later section titled Concept Generation for Improvement of Baseline.

4.7 Eco-strategy

The priority of our business is to reduce water consumption by installing new water-efficient technologies. For this to happen, a payback period for any technology installed must be small enough to meet the needs of the persona. This is addressed in the Requirements and Specifications.

5 Environmental and Social Impacts of the Baseline

Initial domestic/restroom savings calculations have been completed for a school in Michigan as a result of our ethnography research. Toilets, urinals, bathroom faucets and showers were considered in the calculations with usage statistics provided by Zurn [15] and the EPA [1]. Usage and costing details are presented in Appendix C. Greenhouse gas emission calculations and results are provided in Appendix D.

Estimates are for full occupancy during service days, and as such, are conservative. Additional usage will be considered for as data is collected.

Lakeshore High School, in Stevensville, MI, has occupancy of 1,049 for 9^{th} through 12^{th} grade, including staff. Estimates are for domestic/restroom use 173 service days/year.

- Water Consumption: approximately 4.73 million gallons annually
- Water Expenses: $4,726 annually
- GHG Emissions: 5.18 mt CO2 e- annually

The amount of money Lakeshore High School spends is relatively small and only accounts for a small percentage of operational costs as the cost of water in Stevensville, Michigan is $1/1000 gallons. However, if we substitute the cost of water in Atlanta for the same usage as Lakeshore High School, ($30/1000 gallons), the annual water utility cost would be $141,794. This is why we plan to target schools in regions where water is expensive because the impact would be greatest and lucrative for the stakeholder.

Socially, students have a level of water-consciousness equivalent to their parents. This means that some students may be aware of the importance of water and use it more sparingly while some students have no idea about water as a scarce resource and are oblivious to good water consumption practices.

6 Project Description

Our project goal is to provide a working business model that can provide capital free installation of water conservation technologies in academic facilities. Two target personas have been developed as best case and worst-case scenarios.

6.1 Scenario 1 – Best Case

Jacob Smith is a public school administrator for the Atlanta Public School District. He is in his mid-40s, and is married with two children in elementary school. He and his wife met at University; she is an engineer. He grew up and lived in the Atlanta area his whole life and plans to remain in Atlanta. He holds an undergraduate degree in chemistry from a state school in Georgia; graduate degree in education. He makes $100,000 a year as a public school administrator for a school district; he and his wife make enough money to live comfortably; they are able to afford travel soccer for their son, gymnastics classes for their daughter, and summer camp for both children; they eat outside of the home twice a week and take a family vacation once a year. He has a passion for teaching; he began his career as a middle school science teacher in the Atlanta school system before being promoted to his current role as an administrator. His two young children attend school in the school system that he works in.

Jacob does the shopping for the family. He shops at Whole Foods, Trader Joes, and farmers markets on the weekends, and often brings his children with him to instill healthy eating habits. He has some knowledge of environmental problems but is not an activist. He prefers to buy locally grown, organic, and fair trade products but if not easily accessible will settle for traditional products. He drives a Toyota Highlander Hybrid because he likes the idea of a hybrid car but he feels he needs a larger car to drive his children around. He would like to garden and grow his own food but doesn't think he has the time. Sometimes to cut costs and save money he purchases food and household items at a bulk store such as Costco or Wal-Mart.

He worked as a science teacher for 10 years before being offered a position in school administration. His main motivation for getting involved in education is to make a difference in children's lives. He loves children and feels fulfilled in his position as an educator. He enjoys the additional monetary compensation that he receives from being an administrator and accepts the additional income as a trade-off to doing what he loves, teaching. Jacob sometimes misses interacting with students in the classroom. Despite being an administrator, he likes being involved in the schools; he does classroom visits, sits in on teacher staff meetings, and coaches the girl's lacrosse team. He believes he is making a positive impact through education; as a school administrator, he has the ability to set curriculum and schedules for the school, allocate funding to different departments, plan for professional development, and distribution of materials, books, classroom space and equipment. He dislikes much of the bureaucracy involved in education administration. He sees examples of ineffective or uncaring teachers, yet due to unions and contracts cannot remove the teachers from their positions easily. He also must face school panels and paperwork to implement new initiatives. However, he feels that dealing bureaucracy is a necessary evil in his goal to provide the highest quality, tailored education to the students in his district.

He takes cans, bottles, and plastic materials to the recycling center every weekend with his kids. He drinks out of a reusable water bottle and coffee cup and takes his own reusable bags to the grocery store. He likes the idea of sustainability, but doesn't know how he can help or get involved other than what he is doing already. He would like to buy solar panels or increase sustainability within his life but doesn't have the money or time to invest in figuring out solutions.

He wants to create a positive learning environment for all students by expanding programs for special education children, tailoring learning to individual student needs, reducing class sizes, purchasing more supplies such as books, computers, sports equipment, and new furniture for classrooms, providing the best teachers, and offering extracurricular activities such as clubs and sports. He would like to cut costs on non-education related expenses to be able to maximize school programs and extracurricular activities. He strives to be more environmentally conscious and sustainable in ways that he sees are manageable, such as recycling and driving a hybrid car. He is not willing to reduce his lifestyle to achieve sustainability goals. He wants to be a good father and role model for his children and wants his children to model their behavior after his, and he wants to be able to provide for his family and maintain his lifestyle, including sending his children to an expensive private university. Because Jacob is very busy at the school doing everyday-tasks and is busy at home helping take care of his kids, he has very little time to sit down and dwell on ways to achieve some of his goals and therefore, mostly daydreams about the result without heavily considering the actions to take.

6.2 Scenario 2 – Worst Case

Martin Boyle is a public school administrator for the Atlanta Public School District. He is in his late 50s, and is a divorced parent of one child in college. He grew up and lived in the Atlanta area his whole life but wishes to move to somewhere more isolated when he retires in a few years. He holds an undergraduate degree in education from a state school in Washington and a graduate degree in school administration. He makes $100,000 a year as a public school administrator for a school district; he makes enough to live comfortable and send his college age son to a private university in California. He eats out of the home almost every night - mostly take out. He began his career as an English teacher in the Atlanta school district but found dealing with children every day to be draining and difficult, and decided to move to school administration to make more money and get away from the classroom.

Martin does not keep very much food in his house; most of his food consists of frozen dinners and convenience foods such as soups. He eats take out most nights and feels that cooking for himself is a waste of time. He drives a sedan; he doesn't feel that a hybrid is worth the money and doesn't want to sacrifice drivability to be more environmentally friendly.

Martin originally pursued a career in education to make an impact on children. However, he discovered that he did not enjoy teaching; he found it difficult to relate to the students and did not enjoy imposing discipline; therefore, he was not respected by the students and could not bring order to the classroom. He decided to switch to school administration because he still wanted to be involved in schools. He cares about his job and feels that it is important; however, as he gets closer to retirement, he is starting to feel bored and just wants to be done working. He fulfills his role and duties but does not go out of his way to make any changes or create waves. He feels fairly apathetic towards his current role and has begun to get involved in groups outside of the school, especially his church and softball league.

He does not think about sustainability that much; he doesn't feel empowered to be able to make any measurable difference on his own so he doesn't bother. He is not sure about the science behind global warming, and he doesn't think that it will impact him so he doesn't bother thinking about it. He would not want to change his habits to live more sustainably. He sorts his recycling and takes it to the recycling to do his part and believes that that is sufficient and believes sustainability is up to the government to implement.

Martin wants to get through the last of his years working and retire comfortably in Colorado. He would like to be remembered fondly in the school system. He is not willing to do anything that might jeopardize his position at this point. He wants to be able to continue to support his son through college.

Based on these personas, our team strives to install the technology that will impact schools' water use in restrooms and landscaping. We believe our project will be successful as schools are constantly trying to find ways to stretch the few dollars they have and do not have the capital investment required to install technologies that will provide significant savings in the long run. Socially, our project would provide schools with an opportunity to spend more money directly on the education of students. These students are the future of our country and deserve to have a well-developed skill set that will ultimately provide them with the opportunity to succeed in life. In the environmental sphere, a lot of water conservation technologies exists but are not being implemented, so we would be creating more awareness of water conservation technologies and their benefits. In the end, it is possible that the average consumer will be more interested in the investment of sustainable water technologies.

7 Project Requirements and Specifications

Our project aims to reduce water consumption at educational facilities, thus saving the schools money that can be put towards alternative education expenditures. Students would be exposed to the idea of being environmentally conscientious through a short informative session after the installation has taken place. Though indirect stakeholders are a concern for the sustainable design, they are not addressed in this section as the concerns of the school district are most prominent for this discussion.

The following requirements were developed based on interviews of school administrators in Michigan, New York, Oklahoma, and staff in Atlanta. Additional requirements were added that the team deemed necessary based on our own observations. The requirements and subsequent specifications will be used to evaluate concepts for the reduction of water use.

Requirements

1. Any technology and practice implemented **must** reduce water utility expenditures
2. Facility upgrades and technology installations **must** provide a short payback
3. Any technology implemented **must** also provide a meaningful return on investment (ROI)
4. Any installation or program implementation **shall not** interfere with the ongoing educational goals of the facility
5. All technology installed **must** have a long life-cycle to avoid additional facility and educational disruptions
6. Any technology or program implemented **must** abide by existing local, state and federal regulations
7. In order to ensure the safety of the students all contractors **must** undergo appropriate background checks and must meet appropriate hiring standards for an educational facility

Quantifiable and measureable specifications were developed to meet the requirements of the persona. The specifications are technical in nature and provide a direct means of comparing concepts and ensuring the needs of the direct stakeholder are considered and met. Although some of the specifications are based on persona input, a few of the specifications are based on preliminary calculations and intuition. These specifications are believed to be appropriate for the goal of the project and selecting an appropriate concept for reducing water consumption in academic facilities.

Specifications

1. The concept **will** provide a water utility savings of at least 30 percent over the baseline
2. The concept **will** provide a payback for initial expenditure in five years or less
3. The concept **will** provide a ten percent return on investment annually the time the concept is paid off

4. Any technology installations or retrofits **will** occur during extended break periods such as summer, winter and spring breaks to avoid interfering with the education of students
5. Any technology installed **will** have a life-cycle of no less than 20 years
6. All technology and water conservation programs **will** abide by existing regulations
7. All employees **will** undergo background check and drug test to ensure that they are safe to work in an academic environment.

8 Concept Generation for Improvement of Baseline

The scope of this project is to reduce water consumption in schools. In turn the project will capitalize on the need to reduce school operating costs, freeing additional capital for student education, while also reducing the impact on diminishing fresh water supplies. Reducing water usage in schools will also assist in reducing over-utilization of water treatment facilities. The end use of water in educational facilities was considered to generate concept to service this function. Figure 8-1 shows the breakdown of the end use of water in schools. An additional decomposition of water usage areas in schools is shown in Figure 8-2 [1]**.**

Observing these results we see that 73 percent of end water use is attributed to domestic/restrooms and irrigation/landscaping, followed by cooling/heating and kitchen use at 11 and 7 percent. Therefore, more than 90 percent of water use in schools is attributed to only four consumption areas, which the concept generation centered around. That is not to say that other lower consuming areas were not considered as it is possible that some facilities may have consumption areas that can be reduced, though this does not fit into the big picture of reducing water consumption in multiple schools, and must be assessed as site specific water management plans are developed. Moreover, focusing on the highest consumption areas allow the concept to be scaled, increase applicability, and result in a greater environmental impact and reduction in water use. The breakdown and percent use is expected to vary by region, but it is believed the variation will not significant enough to drastically change the outcome of the selected concept.

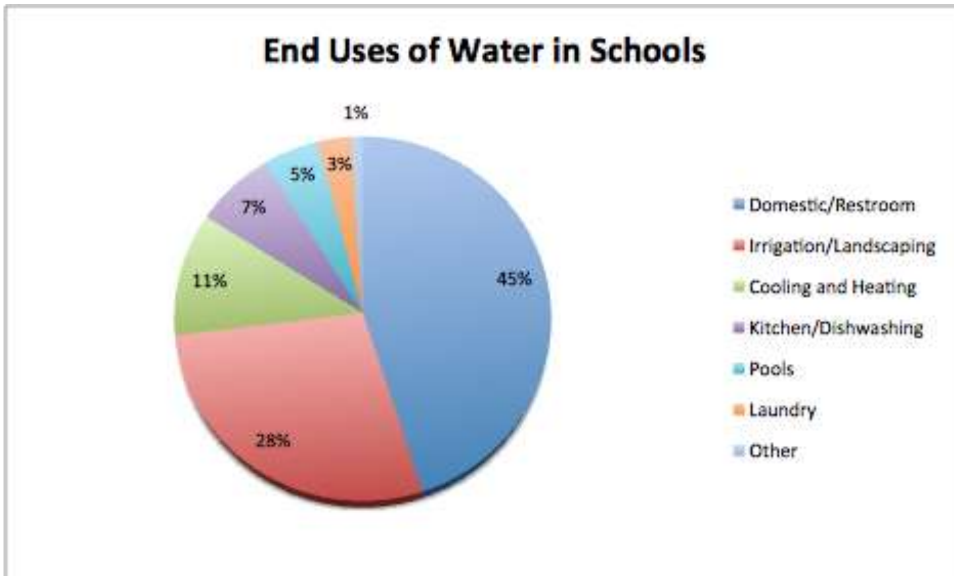

FIGURE 8-1: PERCENTAGE OF END-USE WATER IN SCHOOLS [1]

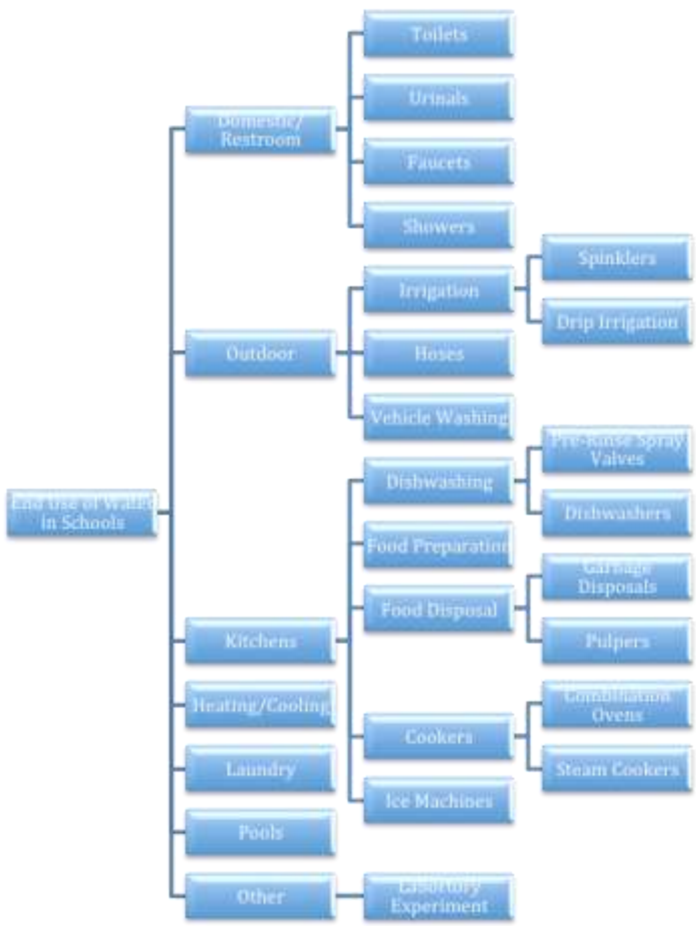

FIGURE 8-2: DECOMPOSITION OF WATER USAGE IN SCHOOLS

Concepts were generated in several categories including: business models and financing; technology installations; water harvesting and repurposing; and education and awareness. These concepts were developed using brainstorming activities such as the SCAMPER technique. The SCAMPER technique encourages creative brainstorming activities to develop or improve existing products or processes/services and stands for: Substitute; Combine; Adapt; Modify; Put to another use; Eliminate; and Reverse [16]. Although, only ten concepts are discussed in detail below, each concept can be individually combined with the others resulting in hundreds of viable concepts. One example is Concept 9, which combines Concept 1 and Concept 2.

The concepts generated include:

1. A knowledge based business model to finance and install water conservation technology with an extended repayment period of up to three years. This concept addresses the financial needs of schools for initial capital costs, has considerable potential to decrease water utility expenses, and provides an opportunity to address water consumption in all of the major water consuming activities, thus generating significant water use reductions creating a meaningful environmental impact. This concept is expected to provide a short return on investment and payback period. The concept is not expected to generate a measurable social impact without a formal or informal usage awareness program. This concept was was modified and adapted from the approach used by SolarCity to equip homes and commercial sites with solar panels requiring no capital cost. An evaluation, implementation and monitoring plan could be developed based on SolarCity's approach, shown in Figure 8-3**.**

FIGURE 8-3: SIMPLIFIED SEVICE PROVIDED BY SOLARCITY

IMAGE SOURCE: HTTP://WWW.SOLARCITY.COM/

2. Developing water awareness via educational programs is the only concept that directly addresses the social impact of need to establish a sustainable design; although, educational programs alone are not expect to generate a significant environmental aspect when addressing water usage in school. This is primarily due to the use of water in schools, which cannot be changed. For example, the largest

consumption area in schools is domestic/restroom use, which activity changes can only generate small savings when compared to component upgrades. Nevertheless, awareness programs educate students which would ideally reduce their water use at school and home and generate a learning cycle passing on conservation knowledge to the community as shown in Figure 8-4.

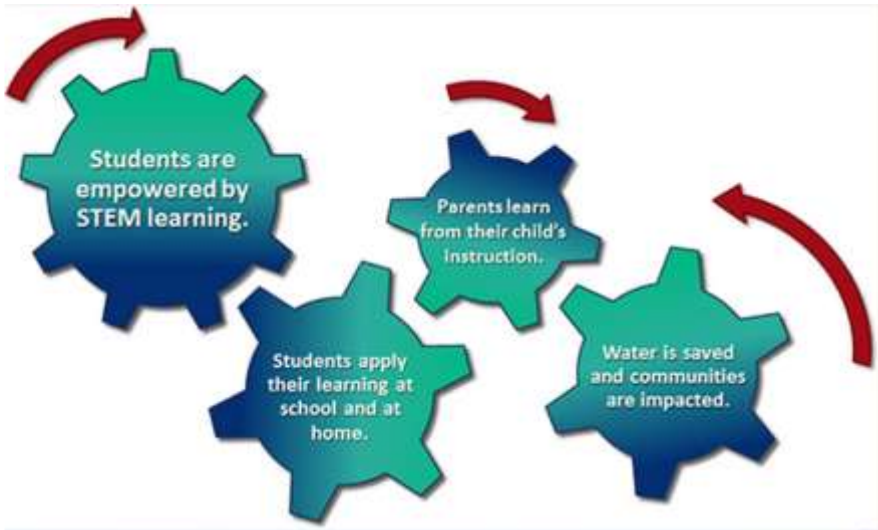

FIGURE 8-4: LEARNING PROCESS FOR EDUCATIONAL AND WATER AWARENESS PLANS

IMAGE SOURCE: HTTP://ARIZONAWET.ARIZONA.EDU/PROGRAMS/SCHOOL_WATER_AUDIT

A sample educational plan known as SWAP, School Water Audit Program, is utilized by the Arizona academic institutions to introduce water conservation concepts through a science, technology, engineering and mathematical program. The SWAP process is shown in Figure 8-5.

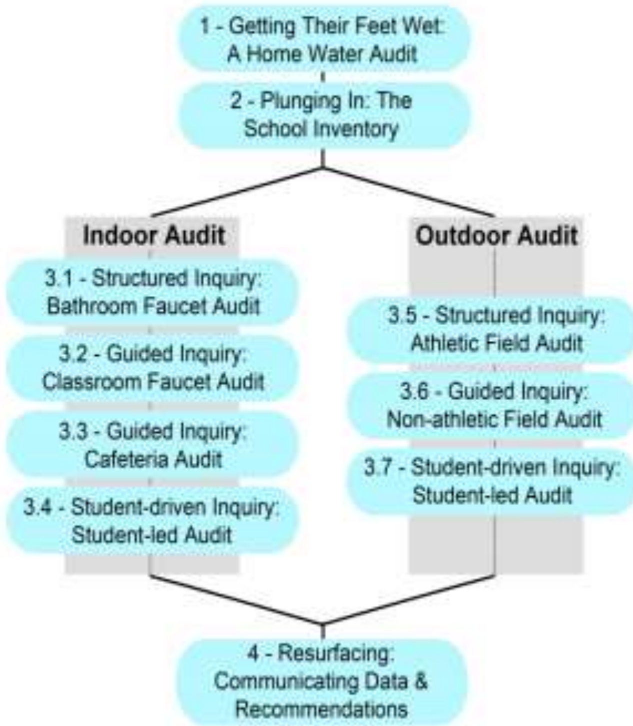

FIGURE 8-5: SAMPLE EDUCATIONAL PLAN

IMAGE SOURCE: HTTP://CALS.ARIZONA.EDU/ARIZONAWET/TEACHERSUPPORT/SWAP

3. A landscaping business to provide the knowledge and service to retrofit landscaping and irrigation equipment is not a novel idea though it does have the potential to offer considerable water and utility savings with a short measurable return on investment. However, the school administrators that we have talked to suggest the end-use percentage of water attributed to irrigation and landscaping has been over-estimated. The scalability and applicability of this concept will be limited if this ethnographic trend continues. Furthermore, the concept does not offer services or products that could not be obtained via a local irrigation business.
4. Design of a new 'net-zero' water use school, or a school that collects, treats, or repurposes as much or more water than its users consume, is an adapted and modified concept from the idea of a 'net-zero' energy home, such as BLUELab at the University of Michigan is pursuing. An example site balance for 'net-zero' water home is shown in Figure 8-6. Adapting the concept to schools would be a difficult as the volume of water consumed by schools is considerably greater than that of an average family home. Additionally, it is unlikely that our persona has the desire or funding to build a

new school to reduce water use - most likely resulting in negative environmental impact as the materials and construction impact would outweigh the water savings for a period of time.

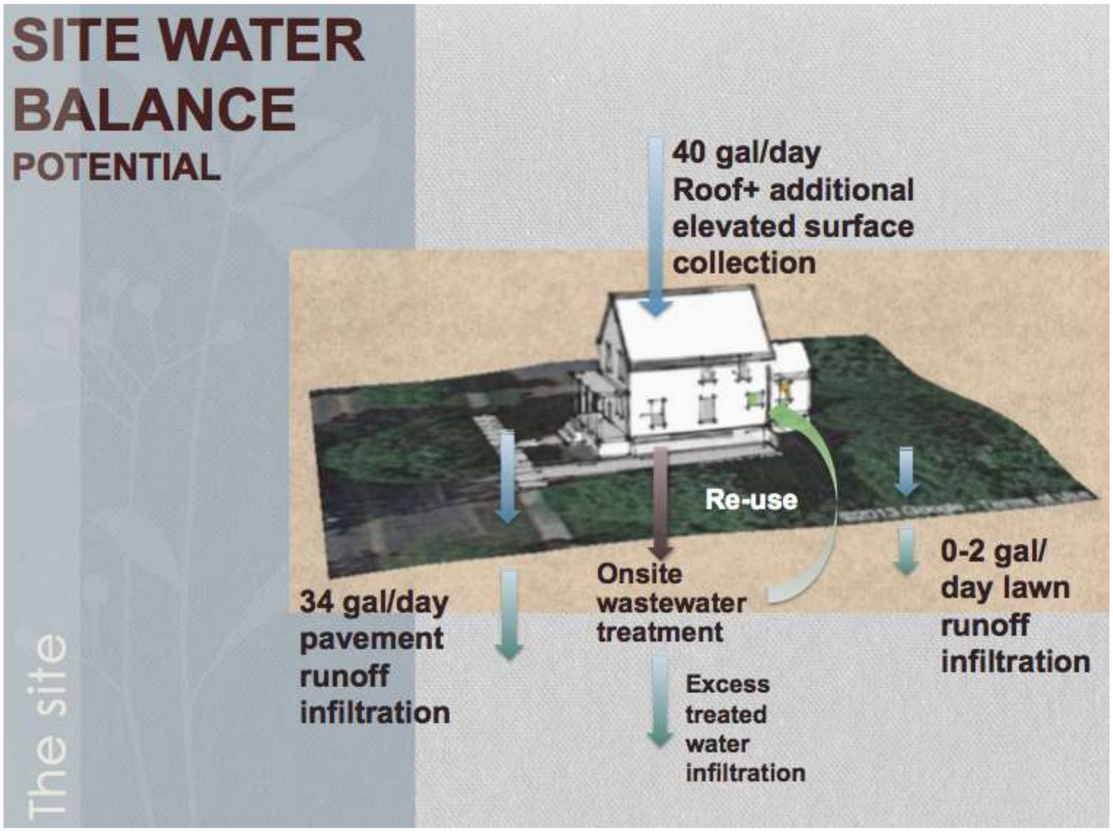

FIGURE 8-6: SAMPLE WATER BALANCE FOR A 'NET-ZERO' WATER HOME

IMAGE SOURCE: BLUELAB

5. Incorporation monitoring technology offers an opportunity for schools to evaluate their water usage pattern and possibly develop and reduction plan. Though, as discussed with water awareness, monitoring is not likely to reduce water use, especially in a short period of time. A sample smart monitor output of daily water uses is shown in Figure 8-7; though, further decomposition of water use is desirable.

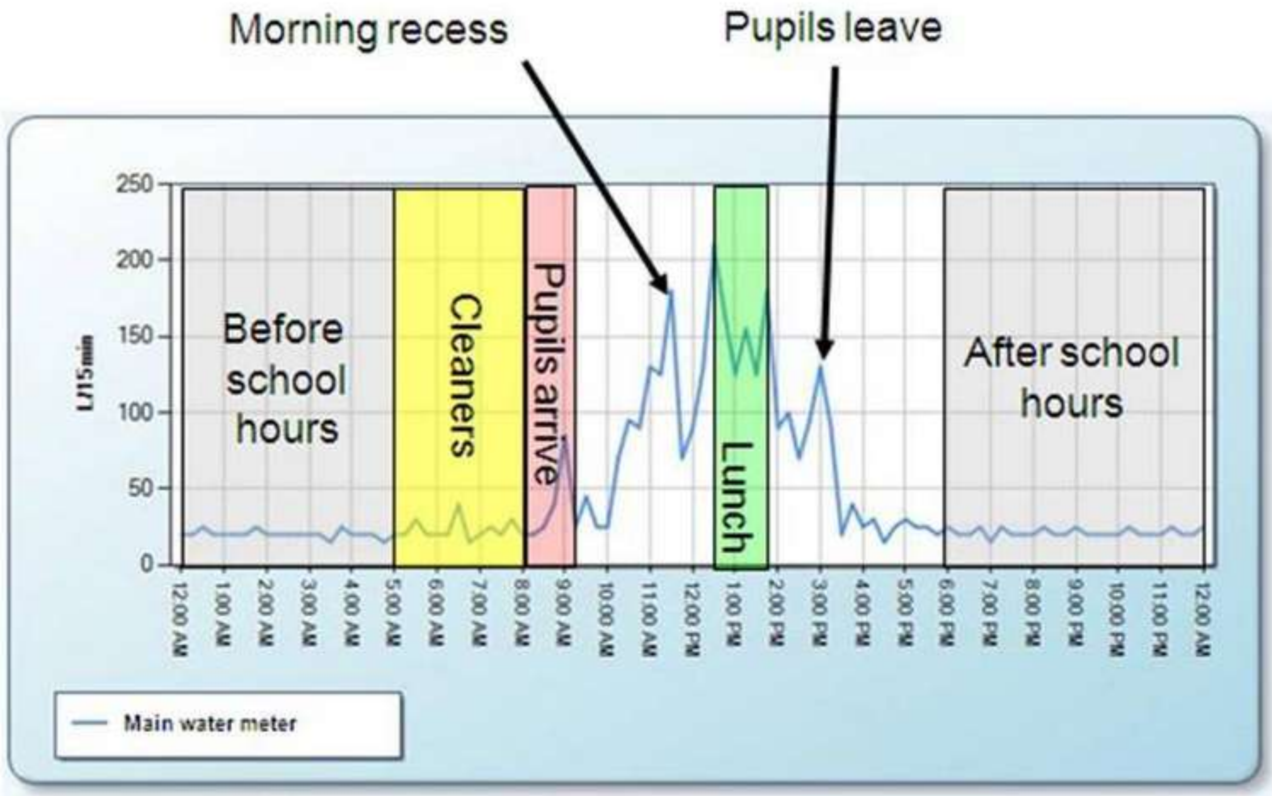

FIGURE 8-7: SAMPLE USAGE MONITOR OUTPUT

IMAGE SOURCE: HTTP://WWW.WATERSAVE.COM.AU/SOLUTION/SMARTMETER-SCHOOLS

6. Rainwater collection and delivery system for indoor or outdoor use offer the perhaps of the greatest opportunity for reducing water consumption, though the initial cost are significant. The idea is to capture rainwater from any surface, such as roofs and parking lots, in a large storage vessel to be used for non-potable applications including: irrigation, toilet flushing, and wash system shown in Figure **8-8**. Though non-potable systems have filtration, more advance filtration options may offer the ability to use the harvested water for other applications. This is expected to significantly increase the cost of the system. Other concerns are implementation including: space requirements for storage and pumping; capacity to meet the needs of the users for extended dry periods, often considered as 30 day or more; and integration with existing outfitting in facilities.

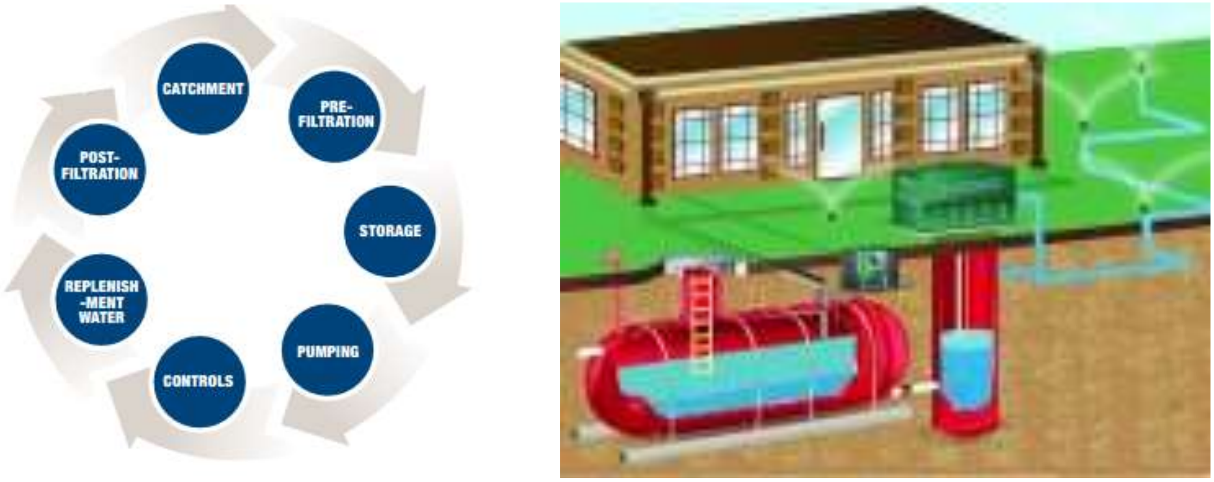

Figure **8-8**: Rainwater harvesting process and system layout [17]

7. Eco-friendly food disposal, such as composting, offers an opportunity to cut kitchen water use, which has estimated at seven percent of the total water budget for schools. The environmental impact related to reducing water use is expected to be less than some of the other concepts, as food disposal are only one aspect of water consumption in the kitchen, though this must be balanced against the cost of setting up a composting practice, the time required to implement the concept, the simplicity, and the beneficial by-product.
8. Utilizing existing equipment for indoor and/or outdoor water repurposing is a practice often used in residential settings, though there is potential to modify the system or incorporate existing systems in a commercial setting such as schools. Repurposed water can be used flushing toilets and some outdoor applications pending local and state regulations, though some concerns do arise when considering sanitation.
9. A business model that meshes educational programs with the aspects presented in concept one is believed to be the only way of achieving a sustainable design when considering the triple bottom line. The benefits of the concept include: immense reduction in water use; considerable return on investment, with a short payback period; and has the ability generate water awareness and social change within the community. Combining to favorable concepts addressed above, concepts one and two generated this concept.
10. Rain barrel water harvesting for outdoor use, i.e. irrigation or landscaping needs, offer the same benefits as concept six at a reduced cost, implementation time, and cost. The collection volume is considerably less resulting in a lower environmental impact and application is generally for outdoor use. In turn this concept will likely not generate the desired of the persona.

9 Concept Selection

The concept selection was completed using a decision-matrix method, or a Pugh matrix. The quality of the selection derived from the Pugh matrix is fundamentally related to the selection criteria, which was determined from the needs of the persona as outlined in the requirements and specifications. Additionally, social and environmental impact criteria were considered with the economic needs of the persona to evaluate the sustainability of the concepts against the triple bottom line. The criteria were weighted based on an importance scale of one to three, one being less important. The weight of the criteria reduces the possibility of skewing the selection decision based on less important criteria. Additional weight scales, such as, 1, 2, 5 and 1, 3, 9 were also considered to evaluate the sensitivity of the criteria, though the results were did not change the top three concepts. The selection criteria are in Table 9-1.

Criteria	Weight (1 to 3)
Social Impact	2
Environmental Impact	3
Capital Cost	2
Potential Water/Utility Savings	3
Payback Period	2
Return on Investment	3
Time to Implement	1

TABLE 9-1: SELECTION CRITERIA AND WEIGHT

After selecting the criteria, each concept was evaluated against the baseline previously described in the baseline evaluation. The baseline is the system that is currently in place and is scored as a ‘0’ against the criteria. Each concept was then compared to the baseline and evaluated to be better, the same, or worse for each criterion yielding a score of +1, 0, or -1. The score is then combined with the criteria weight and a weighted score is determined. The scores are total resulting in a concept ranking. This ranking is shown in Figure 9-1 and Table 9-2.

The decision matrix clearly distinguishes the top three concepts the meet the needs of the persona as:

1. Concept #9 - A business model to finance and install water conservation technology that supplements water savings with water awareness and education
2. Concept #7 - Eco-friendly food disposal program: Though this concept is not expected to generate saving comparable to the Concept #9 and #1, the overall cost and time to implement

pushed this idea into a top three consideration. Uniquely, this idea could easily be incorporated as a technology to consider for financing in Concept #9, the alpha design.

3. Concept #1 - A business model to finance and install water conservation technology

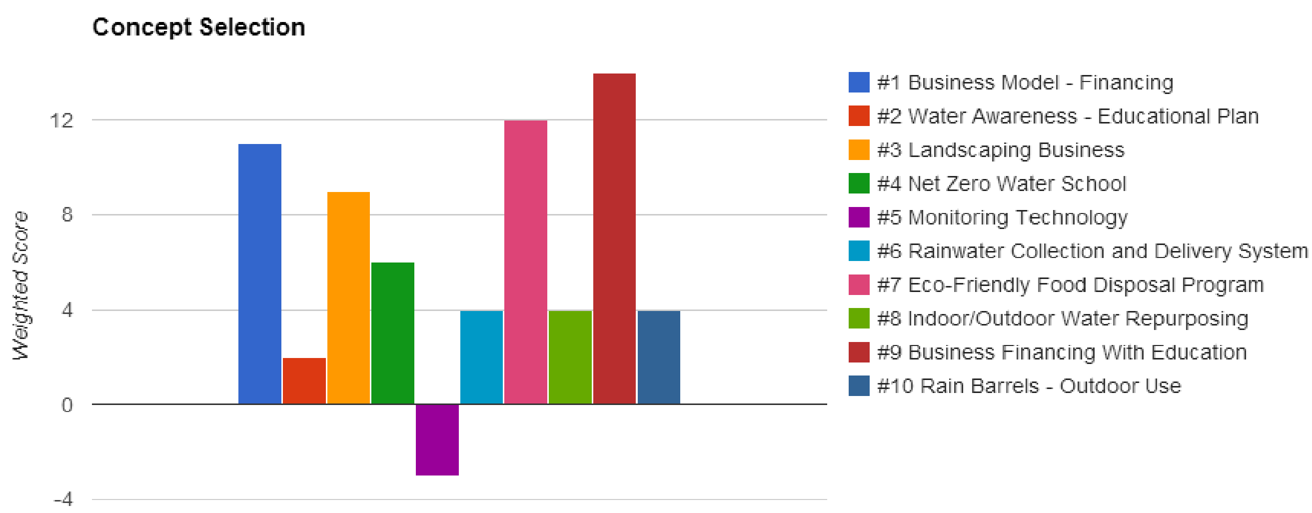

FIGURE 9-1: RESULTS OF SELECTION MATRIX

Criteria	Weight (3, 2, 1)	Baseline	Business Model - Financing (Conservation Technology)	Water Awareness - Educational Plan	Landscaping Business	Net Zero Water School	Monitoring Technology	Runoff Collection and Delivery System	Eco-Friendly Food Disposal Program	Indoor/Outdoor Water Repurposing	Business Financing With Educational Program	Rain Barrels - Outdoor Use
Social Impact	2	0	0	1	0	1	0	0	0	0	1	0
Environmental Impact	3	0	1	0	1	1	0	1	1	1	1	1
Capital Cost	2	0	0	-1	-1	-1	-1	-1	0	-1	1	-1
Potential Water or Util. Savings	3	0	1	1	1	1	1	1	1	1	1	1
Payback Period	2	0	1	0	1	-1	-1	-1	1	-1	1	1
Return on Investment	3	0	1	0	1	1	-1	1	1	1	1	-1
Time to Implement	1	0	0	-1	0	-1	1	-1	1	-1	-1	1
Sum of Positive		0	4	2	4	4	1	3	4	3	6	4
Sum of Neutral		0	2	3	2	0	3	1	3	1	0	1
Sum of Negative		0	1	2	1	3	3	3	0	3	1	2
Weighted Score		**0**	**11**	**2**	**9**	**6**	**-3**	**4**	**12**	**4**	**14**	**4**

TABLE 9-2: CONCEPT SELECTION EVALUATION

10 Preliminary Alpha Design

Although the selection matrix provided three closely ranked concepts, concept #9 was selected as the alpha design. The concept, as addressed above, is to provide knowledge based service to evaluate and finance the installation of water conservation technology and develop water conservation practices that can be supplemented with water awareness. The business model addresses the need of schools to reduce their operating budget, frees up additional funding for student education and extracurricular activities, has the potential to reduce water use in schools by 30 to 50 percent based on initial savings estimates, decreases the amount of water being sent to water-treatment facilities that operate at or over capacity, and when coupled with an educational plan, offers an opportunity to create water conservation awareness and establish a social change. This was concept was not only selected because it was the highest rated concept in the decision matrix but also because the system is believed to best meet the needs of the persona. Concept #9 is believed to reduce water consumption the most, provide the greatest return on investment in a short period of time, and best address the triple bottom line in sustainable design. Figure 10-1 shown below provides a summary of how our business model will function to provide schools with conservation technologies.

FIGURE 10-1: DIAGRAM DEPICTING THE PROPOSED SERVICE PROCESS

While there are many end-uses of water consumption in academic facilities, we selected to focus on restroom water use for our business start-up since it comprises nearly 50 percent of schools' water consumption. One way the reduction in restroom water consumption can be achieved is to update the current fixtures (toilets, urinals, sinks, and showerheads) with water-efficient fixtures, such as, low flush toilets and faucets with aerators. Reduced consumption can also be achieved by installing a rainwater harvesting system that is used to supply non-potable water in appropriate applications, e.g., toilet water. However, in some states harvesting rainwater is illegal while in other states there are many regulations to deal with if a harvesting system is to be installed. This makes the installation of a rainwater harvesting system difficult to implement. Further, the economics of a 2,500 gallon rainwater harvesting system were evaluated, and the payback period of the system, 8.5 years, does not meet the requirements and specifications of our design. A detailed evaluation of the rainwater harvesting system can be found in Appendix E.

Additional water conservation areas should be considered as the concept is developed. For example, some inexpensive steps can be taken to reduce water use for irrigation and kitchen use; though, we were unable to collect sufficient water use data to appropriately calculate the expected impact in these areas. Nevertheless, the alpha design is not so specific that these practices cannot be implemented at a later date after adequate data is collected.

11 Feedback and Response to the Preliminary Alpha Design

While we have not conducted any surveys or held focus groups to validate our business model, we have received positive comments from interviewees, corporate executives and University of Michigan faculty who were in attendance at the Engineering Design Exposition on December 5, 2013. A brief summary of each testimonial is provided below.

<u>Michael Mulligan - Principal at Lakeshore Public High School, Stevensville, MI:</u>

When interviewing Principal Mulligan about school operations and the bathroom renovation project Lakeshore High School underwent in August 2013, he responded to the general idea of reducing water consumption/the utility bill with the following statement:

"Every $1,000 saved counts. Hell, every $100 matters when you're talking about education."

Although his testimonial occurred before our alpha design was created, it shows that there is a serious turn-key in marketing to schools. Any money schools can save, or "free-up," is a big deal when trying to provide students with a good education.

<u>Kevin Self - Vice President of Strategy and Corporate Development at Johnson Controls</u>

Kevin Self was on campus to speak at the University of Michigan's Energy Symposium. After the conclusion of the speeches from distinguished scholars and corporate executives, one of our team members asked Kevin what he thought of a business model that provides the upfront funding and installation of water conservation technologies. His response is summarized below:

"...today we talked about energy and the need to use it sustainably, when in reality water is a serious issue that is currently being overlooked. A business model to provide water conservation is definitely something for the future providing that a legitimate need is found..."

<u>Unknown Faculty Member - University of Michigan</u>

At the engineering design exposition, a person - presumed to be a professor - came by our design poster and consequently a discussion began. He inquired about why we chose restroom/domestic use (it is where most water is consumed). He also asked a few highly detailed questions about considerations we were making regarding irrigation/landscaping water use. Before moving on, he stated *"...this is great project; really excellent."*

Lockheed Martin

Also at the engineering design exposition, a former University of Michigan Engineering student and current Lockheed Martin employee stopped by to discuss the challenges of water shortage and prices. He is from Denver, where water prices are also extremely high, as is the case for our target markets. He stated that "… Many people focus on energy efficiency. But no one thinks about water shortage because it's usually a small portion of an organization's budget." He praised our project, and said that he could see real value in our business model.

Jeff Carlson – Assistant Superintendent of Business, Three Village Central School District, Setauket, NY:

During our interview with Mr. Carlson, he addressed many of the challenges that he faces to implement new capital projects. We discussed many of the funding challenges and the attractiveness of a business that would provide the upfront capital and capture a portion of the generated savings.

"When implementing capital projects, we face heavy budget and cost issues. We currently have a tax cap in New York State where we can't increase taxes by more than 2% or Consumer Price Index, whichever is lower. This makes new projects difficult to finance when we need to deal with contractual salary increase, health insurance, retirement, have needed to cut staff; it is hard to add new things when we're cutting staff. We would appreciate the upfront capital financing. This project is kind of what we're doing with the LED lighting – same idea, we are paying for the installation of the new lighting fixtures with the savings on the new electricity, already have a similar business model for energy efficiency."

Cheryl Pedisich – Superintendent of Schools, Three Village Central School District, Setauket, NY:

Ms. Pedisich discussed some of the energy efficiency projects they had recently implemented in the district, and the value that Johnson Controls provided above and beyond the efficiency installations with the educational content they provided.

"During our energy efficiency project, Johnson controls came and met with students and teachers in classrooms. There is definitely an educational component; they offered it upfront as

part of their proposal to us. It is always appealing from an educational perspective; we are always looking for that educational piece as an incentive."

Although we have received many positive remarks, they are not sufficient to ensure that we have taken all of the necessary steps, considered all of the pertinent concerns of the persona, or adequately addressed the challenges that new businesses face, and thus, we believed that it is necessary to continue collecting the necessary feedback. To do so we recommend pursuing a panel discussion with leading experts including: professors, graduate students, school district administrators from across the U.S.A., technology experts, and entrepreneurs. This will help the team to establish the next steps and address deficiencies not yet considered. Moreover, we believe it is necessary to get in contact with as many school administrators as possible, perhaps by sharing the necessary information and performing a survey.

12 Final Concept Description

Our final design concept is to establish a business that provides K-12 schools with the capital financing and installation of water conservation technologies while incorporating an education component to spark the water conservation dialogue amongst youth. The start-up location for our business is Atlanta, GA because this is where water is most expensive in the United States at $30 per thousand gallons. The initial, focus area of end-use water to be reduced is that of restroom/domestic use. Based on economic evaluations of payback periods and overall ease of implementation, the water conservation technology to be installed will be efficient restroom and locker room fixtures, including toilets, urinals, faucets and showerheads. As our business expands, we can look further into landscaping, irrigation, and kitchen water consumption to develop a technology installation plan.

The service we developed is environmentally sustainable as it will conserve water - a highly undervalued resource that is currently being used at an unsustainable rate - without making a larger environmental impact in its implementation phase. Socially and economically, our business is sustainable as it helps schools save on operational costs. This allows schools to increase their budgets for the direct education of students, which could take form in better learning materials or additional staff. Another socially sustainable aspect to consider is the education component of our service. We hope that by teaching students about the importance of saving water and providing ways to reduce consumption, that they will carry this information and practice water conservation strategies throughout their childhood and into adulthood.

13 Improvements of the Alpha Design over the Baseline

Figure 13-1 shows a graph of cumulative water consumption with current technology against the net water consumption with updated technology over a period of 20 years. This timeframe was selected as the average lifetime of bathroom fixtures is twenty years [12].

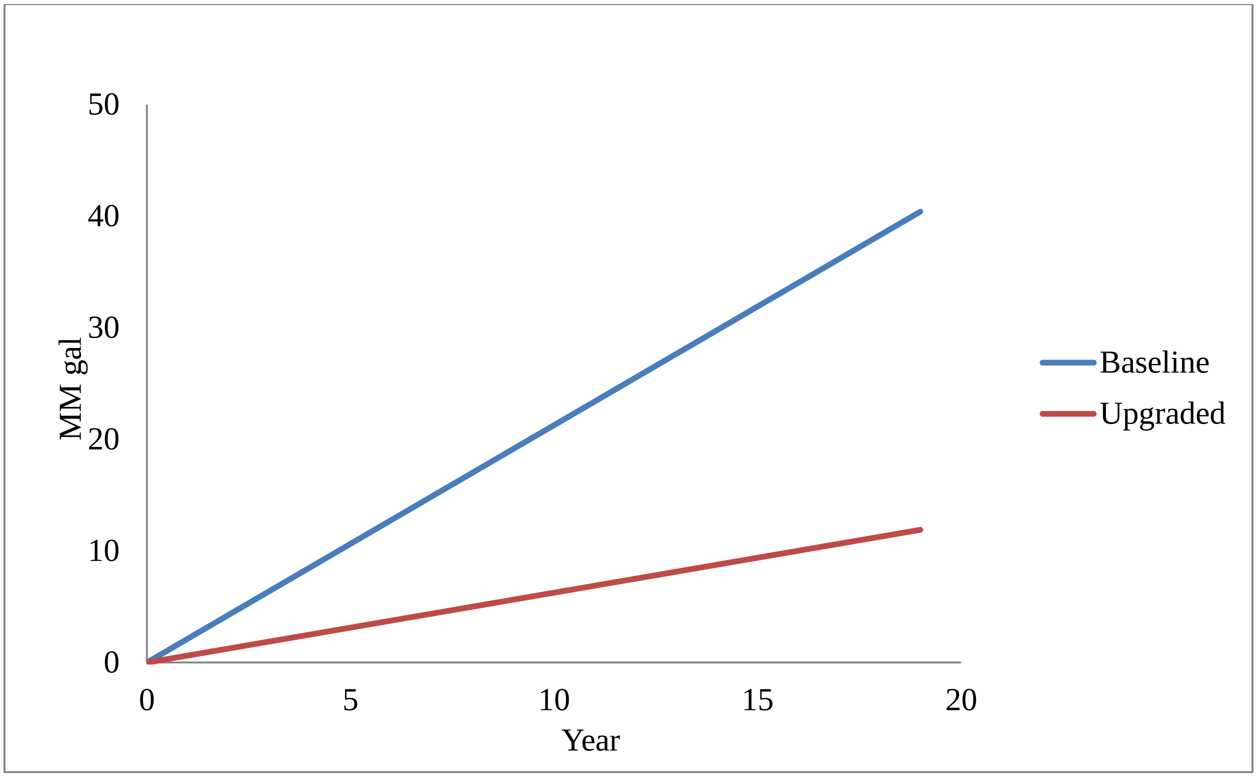

FIGURE 13-1: PROJECTED CUMULATIVE RESTROOM WATER USE AT LAKESHORE HIGH SCHOOL OVER 20 YEARS

From the chart, it is positive to see that with updated restroom fixtures, water consumption over 20 years will be approximately equivalent to water consumption over 5 years with the original fixtures. This means that potentially 15 years of water usage can be eliminated from the installation of new technology. Table 13-1 shows the baseline, annual restroom water consumption compared to the alpha design water consumption.

Baseline (MM gal)	Upgraded Fixtures (MM gal)
2.127	0.626

TABLE 13-1: ANNUAL RESTROOM WATER CONSUMPTION OF BASELINE AND ALPHA DESIGN

The alpha design cuts restroom water consumption by about 70 percent, which is equivalent to a savings just shy of $45,000 annually. Over 20 years, this savings amounts to $900K - almost one million dollars. When we look at the reduction in restroom water consumption compared to total water consumption of the school (4.726 MM gal), we are looking at an overall reduction in water consumption by approximately 32 percent.

Table 13-2 and Figure 13-2 show the GHG emissions of the baseline and alpha design over a 20 year fixture lifetime in numerical and graphical form, respectively. Calculations of baseline and alpha design emissions are detailed in Appendix D.

Baseline (mt CO2 e-)	Upgraded Fixtures (mt CO2 e-)
109.01	37.43

TABLE 13-2: TOTAL GHG EMISSIONS OF BASELINE AND ALPHA DESIGN AT 20 YEARS

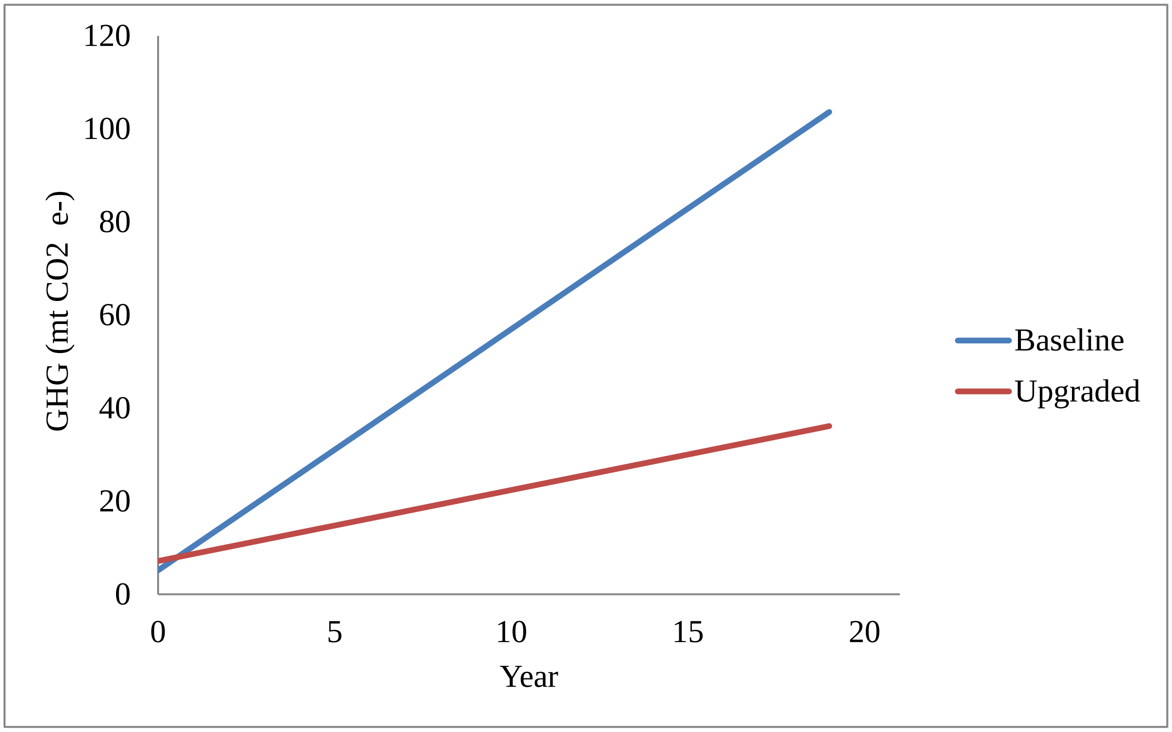

FIGURE 13-2: CUMULATIVE GHG EMISSIONS COMPARISON OF BASELINE TO ALPHA DESIGN OVER 20 YEARS

From upgrading bathroom/domestic fixtures, GHG emissions can be reduced by approximately 66 percent. It is important to note that the installation of these new fixtures exceeds the GHG emission savings from the use phase at year zero, as seen in Figure 13-2, but over the lifetime of the fixtures, the overall GHG emissions decrease. Therefore, we can conclude that our business model is proven sustainable, and is not a "green-washing" design based on both, reduced water consumption and GHG emissions results as further discussed in the Sustainability Evaluation Section. Figures similar to Figure 13-2 have been created for each technology installed (toilets, urinals, faucets, and showerheads) and are provided in Appendix F.

From a social aspect, the students will be subjected to an educational session about water, why it is important that we conserve it, and easy ways to reduce water consumption. The effect of this educational session cannot be predicted accurately, but we at least present an opportunity for kids to learn about sustainability in the realm of water and eventually become more conscientious consumers of water at some point in their lives.

14 Business Plan

Water Wise LLC's business objective is to provide water conservation technology, conservation knowledge and expertise, and capital project financing to cash strapped public schools. There are a number of water conservation technologies currently on the market, yet they are not widely implemented due to high upfront cost and relatively long payback periods. Our business will provide three key benefits:

1. Schools are constrained by tight budgets, increasing healthcare and retirement costs, and tax caps, and often cannot afford the high upfront cost of conservation technologies.
2. Provide a one-stop, total water conservation solution. Water Wise will facilitate a water audit to determine the areas with the largest potential savings, provide upfront capital financing, facilitating the connections to equipment manufacturers and construction crews, and provide continued support and consultation.
3. Provide an educational component to students in the form of assemblies, an after school club, and a recommended curriculum for schools.

We will focus on the domestic/restroom use, updating the toilets and urinals with low flush systems, and installing low flow faucets and showerheads.

The business will recover the initial capital expenditure plus a sustainable profit by collecting a percentage of the savings over five years. Our target market is schools in high water cost areas. We plan to target the Atlanta, GA school district initially by employing a direct selling strategy. From there, we will look to expand to other cities such as, Seattle and San Jose in years three and four, respectively.

14.1 Company Description

The legal name of the company will be Water Wise, LLC. The business will be formed as a Limited Liability Company in Georgia due to the tax benefits associated with an LLC formation. The business will be a hybrid consultancy/finance service. We will provide baseline suggestions for water conservation technologies, based on a water use audit. Water Wise will be owned jointly by its three founders, Jimmy Gose, Denise Cherba, and Amanda Aweh, who will be active participants in management decisions.

Water Wise's business model will closely mimic many business models popular in the solar industry. Our business provides a total water conservation package to schools, including technology selection, installation, and financing. The initial investment will be provided by Water Wise, and will be paid back by the schools, including a discount rate and sustainable profit, by capturing a portion of the savings generated by the system. This system appeals to schools looking for cost savings, as the project will generate cost savings immediately without the challenges of filing for capital financing from the school board. Finally, our system will include an educational component, consisting of an assembly and lesson plans to be incorporated in the school curriculum.

14.2 Market Analysis

We determined ten cities that would ideal locations, based entirely on cost of water and size (See Appendix G). We plan to initially target one city in year one, with plans for expansion to a second city in year three, and a third city in year four. The three target cities have been selected based on water cost, however, may be subject to change based on receptiveness of school boards and changes in water utility costs.

There are many companies that manufacture and install efficient restroom fixtures. Recently, in our target city of Atlanta, GA, TOTO USA, a manufacturer of commercial and residential plumbing products, has been partnering with local businesses and government agencies to upgrade outdated plumbing fixtures. TOTO offers a much wider range of products, and can install many different kinds of fixtures dependent on customer needs. However, these companies generally do not offer, or offer very limited, upfront capital and project financing. Similarly, there are many nonprofit organization that offer free water audits to schools and offer suggestions and expertise to reduce water consumption. These organizations have the expertise to audit the entire system and generally have name recognition. They are also ideal partners for schools because they are both non-profit organizations. However, they do not actually offer any installation services, so once the audit is complete, the schools must find a different company to carry out the water improvements and generate the capital for the improvements.

We plan to attract schools to our business by providing all of the upfront capital. Our pricing strategy is based on recouping the cost of the system plus a reasonable profit over a five-year period, including a five percent discount rate to account for the cost of capital. Because our business strategy is to provide the equipment at no upfront cost to the school, we will take a large percentage of the savings generated as profit. In the best case, we will take 80 percent of the yearly savings as profit for each school for five years, while in the average and worst cases, we will take 75 percent and 50 percent, respectively. At the end of the five-year period, the customer will own the equipment and all savings generated. According to the Atlanta Public School District, average useful life of the water conservation equipment is estimated to be 20 years, so for 15 years, the school can expect to reap the entire benefits of the system [18].

A major barrier to our entry into the industry is the difficulty we will face in gaining entry into schools. Due to the nature of educational facilities, school districts must be especially conservative about soliciting outside contractors. The school board must report to tax payers, and must be elected, and therefore will be much more risk adverse. Despite offering zero upfront cost and immediate cost savings, school officials may be hesitant to invest in a company that does not have a proven track record. Additionally, they may have safety concerns for the children in the school when engaging with a relatively unknown company. Another barrier to entry is the actual capital. The business will require a relatively large upfront investment in traditional start-up costs and capital to complete the first few projects. Once the business has been operating for four years, we expect to start making profits.

14.3 Product Description

Water Wise's water conservation package will result in the following benefits for the customer:

1. Will not require any upfront capital cost, so the school administrators will not need to include a large capital expenditure in the budget or require approval by tax payers, and the approval process by the school board will likely be quicker
2. Provide total water conservation solution so that the customer will not have to have multiple contracts. This will be a turnkey solution for the customer.
3. Performing a water audit will ensure that the project is actually beneficial and the savings are measurable.
4. Projects can be cash flow positive from day one.
5. By providing full system support, we will eliminate system performance or operating risk for the customer
6. The projects will demonstrable school's environmental commitment
7. Potential increase in property value of the school
8. Provide educational curriculum to be incorporated into the science curriculum

Water Wise has a competitive advantage over the other corporations and not for profits operating in the water conservation space because we are offering the entire value chain, requiring only one contract. The installation will be a turnkey solution for the school. Water Wise will provide water conservation technology consulting, capital financing, facilitate the connections to equipment manufacturers and construction crews, and bring an educational component to students specifically targeted to address the unique challenges that schools face. By providing all of the activities on the value chain, our company will greatly increase the ease of implementation for water conservation technology, and reduce the administrative burden for school administrators.

We have spoken to a number of school administrators who are interested in water conservation technology, and gauged their reactions to our business model. All reacted positively to the idea of providing the capital financing, and paying for the installation with the savings generated. (See previous section for customer testimonials.)

Currently, the business is in the idea stage. We will require additional customer feedback, more accurate cost projections, and a point of contact in our target schools before we can begin to invest capital and begin to form the actual business.

14.4 Marketing and Sales Strategy

We plan to begin in Atlanta, GA, where water costs are $30 per 1000 gallons. We will then move to Seattle, WA in year three, or once we have achieved 25 percent market share in Atlanta, and then move to San Jose in year five. In each market, we will target one school to pilot the project in the year of entry, and expand to additional schools upon successful completion of the pilot. For the pilot, we will select a high school in the target area, with an older infrastructure as compared to other schools in the area, and at least as many students as our sample school that we used for our calculation. By targeting a school similar to our sample, we will be able to anticipate the required labor needs and have a robust estimate of the potential savings. See Appendix G for market penetration details for Atlanta, Seattle, and San Jose.

To market our product, we will focus on direct selling to school districts, which is cost effective, as the school board for Atlanta oversees all of the schools in the Atlanta area. We will also attend educational conferences in our target geographic locations and place ads in educational publications with circulation in our target geographic locations. We will utilize an internal sales force to sell directly to customer. One of our main competitive advantages is the ability to provide one point of contact for all of the stages of the project, from assessment through installation and continued maintenance. As these projects are large investments of capital, time, and resources, school officials will not want to work with a third party at any point in the project.

Water Wise initially plans to expand geographically, beginning in Atlanta, and moving to different cities with high water costs, starting with Seattle in year three and San Jose in year four. Water Wise will continue to expand to high water cost areas, striving to achieve 50 percent penetration in each area. We assume that we can achieve 50 percent market penetration in each area of focus, based on a study of Johnson Controls, which entered the market in Long Island and won bids at 60 of the 125 school districts [19].

Eventually, we will saturate the market for schools in high water cost areas, and will need to find alternative sources of revenue. At this point, our business model can be expanded to other government buildings and large not for profits that face similar budget challenges as schools. We will not have the added benefit of offering educational curriculum; however, these organizations would have capital financing challenges and resource constraints similar to that of schools. We can utilize our name and expand in the high water areas that we are already located.

14.5 Financing

Our main drivers of cost are the technology for installation and personnel, both construction and sales force. Our per-unit cost estimates for the installed technology include installation costs, including labor. (See Appendix I and J for a breakdown of costs per installation and payback period calculation. See Appendix K through P for projected installations, Income Statements, assumptions, and Statement of Cash Flow for best, worst, and base case.)

In the base case, we expect to turn a positive profit by year four and breakeven by year six. Revenue collection will be delayed due to the contract terms, which is why it will take a number of years to have a positive return on investment. Actual results will likely range from the best to the worst case. In the worst case, we will only collect 50 percent of the savings generated, and installation costs will be the highest possible. We do not believe there is a high likelihood of this scenario, based on studies of similar business models of solar companies.

This business model will require a high upfront investment to provide the initial financing for the installations. We anticipate an initial capital requirement of approximately $148,000 to cover our initial startup costs and year 1 and 2 expenses when revenue is low. See Appendix H for projected startup costs. We will pursue financing from University of Michigan venture capital sources, such as the Frankel Commercialization Fund and Wolverine Venture Fund, run by MBAs at the Ross School, as well specialized small business loans from the city of Atlanta, which offers lower interest rates.

15 Design Critique

In completing ethnographic research, it would have been valuable to have more time to do a more thorough observation of school water use, which is the basis for our improvement and predicted financial success is based upon. We were not able to include other end-use water areas in our business plan with any great detail because we weren't able to obtain much information.

Ideally, spending some time in schools located in the major regions of the United States would be extremely beneficial to get better estimates of baseline water use and what kind of water conservation technology is most feasible to install. Our business plan has a lot of uncertainties included in it because water consumption at a school may not be the same year-after-year as the number of students and faculty can change. This is where looking at the water-consumption in schools over 5-10 years would be beneficial in determining if our business can be successful financially.

Another concern for our business is the current moves that cities and school districts are taking to cut energy cost, including water utilities. At least a few school districts such as San Francisco and Sante Fe are embarking on ventures to cut school energy cost by ten percent annually, and at least according to according the Sante Fe School District, they are making steady progress. This suggests that in at least some markets schools have the ability to embark on water conservation project of their own. Further delay in rolling out the business plan could result in considerably lower market penetration or at least suggest some market variability by region.

Additional concerns include the actual cost of the technology and installation. The best and worst case business scenarios consider a wide range of costs though this provides at least some uncertainty to the savings and profit predictions. These costs will need to be evaluated more closely moving forward.

Moreover, other end-use consumption areas need to be considered. We are currently offering about 30 percent saving primarily by considering domestic/restroom use; although, we believe that we can offer an additional five to ten percent savings for irrigation use at a small cost compared to the technology cost of the domestic/restroom retrofits. Thus, additional exploration in other end-use area should have already been considered and will undoubtedly need to be considered moving forward.

The business plan also includes a number of assumptions surrounding some uncertainties. Given that our business model is a new application of water conservation, the closest similar businesses were Johnson Controls and solar companies such as SolarCity. We modeled our market penetration strategy and marketing strategy after what had been successful for these companies, however, until actual market entry occurs, it is difficult to predict market reception. Additionally, we used estimates for costs based on business plans from related start up consulting companies, however, given more time, we could have researched every line item, including utilities, employee salaries, and startup expenses. If actually launching the business, we would have done more in-depth research and contacted vendors for quotes. Finally, we used the Atlanta water rates as a best predictor of water cost in all areas that we might expand to. It would have been more accurate to use actual water costs in other areas to predict actual savings, but in the interest of time and due to uncertainty of expansion locations, we used Atlanta as an estimate.

16 Recommendations

The following list present several recommendations for moving the project forward and are critical for establishing firm footing in the market:

1. We need to research and assess the viability of water conservation technology in irrigation, kitchen and other end-use applications ensure that we are generating as much water saving as possible without over-extending the costs of the upgrades and practices.
2. To gain entry into our target market, we must identify and contact school administrators in our target locations. Getting our first client will be very difficult without a proven track record, so we must be open to exploring a number of different target locations.
3. We must identify and enter into contracts with important partners. We would like to partner with a company providing water audits. We also need to identify manufacturers of the technology we will be implementing, compare prices, and negotiate for quantity discounts.
4. We must create the content for the educational curriculum. We have determined that the best format for the educational curriculum will be in the form of assemblies and curriculum to be integrated into the existing science curriculum, however, once the project is past the design phase, we can begin to develop the actual content to be included in the curriculum. This curriculum must be tailored to different age and ability levels for different schools.
5. We would like to assess the applicability of our model to government or not for profit organizations that face financing challenges similar to schools.
6. To assess the potential of financial viability, we would like to pitch our project to a group of investors to assess the attractiveness of investment in our business. This will also serve to provide valuable feedback.

17 Acknowledgements

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List of Appendices

Appendix A: Interview Transcripts

This Appendix provides transcripts of all interviews conducted at present.

Interviewee: Michael Mulligan

Occupation: Principal of Lakeshore High School in Stevensville, MI (Berrien County)

Date of Hire: Fall 2011

Past Employment: Principal of Dowagiac High School; Principal of Constantine High School (both within a one hour drive of Stevensville, MI)

DENISE: Hello Michael, my name is Denise Cherba. Brian Samuel forwarded you an email I wrote about hoping to do research here at Lakeshore. I'd like to thank you for being so receptive and cooperative.

MULLIGAN: You're welcome. So what's this project you're working on?

DENISE: My team at UofM is investigating the concept of providing the free installation of water conservation technologies at schools where the cost of water is high and increasing at a high rate. The school would then pay us back with the percentage of money they are saving from reduced water costs.

MULLIGAN: Water is really inexpensive here.

DENISE: That may be the case. However, we need to be able to get a baseline of water consumption at a high school so we can figure out accurate numbers regarding the end-use of water in schools. This will help us determine what conservation technologies should be employed.

MULLIGAN: Well, you know we just renovated all the bathrooms. All the toilets and faucets are automatic.

DENISE: Yes, I happened to notice that when I used the restroom earlier. When did this renovation occur?

MULLIGAN: August 2013; cost us about $750K

DENISE: Oh, wow. That's really recent. Where did the school get the funding for this project?

MULLIGAN: The Student Foundation Allowance...which comes from the state. We get about $7000/student.

DENISE: Is that a high allowance? What kind of budget cuts have you been experience at your previous jobs and here at Lakeshore?

MULLIGAN: Well, students are now paying to participate in athletics. It's $75/student per sport or a cap of $300 for families with more than one student athlete. In terms of faculty, Lakeshore has had to let go 10 faculty members over the last five years.

DENISE: So, I stopped by the administration office and Tracy, the CFO, said that the water bills aren't really a big expense here. What do you think?

MULLIGAN: *pulls up the maintenance and operation costs associated with the high school on his computer. The operations/maintenance is about 8.45 percent of the school budget which amounts to just over $1M.*

DENISE: Well, 8.45 percent doesn't seem like a very significant amount to try and reduce. Hopefully this is not the case at schools in the regions we are looking at.

MULLIGAN: It may be a small monetary amount, but each extra $1000 - heck every extra $100 you can get your hands on is worthwhile.

DENISE: That's very promising to hear. So if you don't mind, I'd like to go back to the bathroom renovation. Can you tell me more about it?

MULLIGAN: Sure, they put in electric toilets and sinks, made the bathroom space larger, re-did the floors, walls, ceilings. Everything. They didn't consult me on the changes, but I would not have gone for the automatic feature on the toilets.

DENISE: Oh?

MULLIGAN: At the last school I worked at (Constantine), the power repeatedly failed. If we had had automatic toilets there, no one would be able to go to the bathroom. What happens now if the power goes out here? You won't be able to use the toilets or sinks.

DENISE: That's an incredibly good point as there are efficiency valves that are operated manually. I wonder why they didn't choose that option.

MULLIGAN: Yeah. There are also plans to replace all the windows in the school to eliminate the draftiness. The main reasoning wasn't to reduce heating and cooling costs, but more for comfort.

ME: Interesting; I'm sure a bit of heating and cooling savings could be seen from that venture.

Staff member walks in to talk to Mulligan; I am forced to exit.

DENISE: Thank you so much for being so cooperative and allowing me the opportunity to come here and do some digging into school water use. I will let you know how the project turns out.

MULLIGAN: You're welcome and good luck. If you need any other data or information please feel free to email me later on.

DENISE: Great; thanks.

Appendix A: Interview Transcripts

Interviewee: David Perpich – Friend

Occupation: Worker at Sachse Construction in Ann Arbor, MI (been in construction for around 30 years)

Hobbies: Past rugby player and coach.

PERPICH: Alright, Cherbs. I don't have a lot of time. Give the 2 minute low-down.

DENISE: Okay, I'm working on a project where we are installing various water conservation technologies into schools *cutoff by PERPICH*

PERPICH: Alright, there are 4 different things you have to consider: The human labor, the technology you are installing, the tools required for the installation, and the infrastructure of the existing building. You need to know if it's a high school or an elementary school. Elementary schools have full kitchens while high schools have serveries. Next you need the blueprint; it's a public building so it's blueprint is accessible at the City Hall. Now, give me an example of what you want to install.

DENISE: A low flush toilet

PERPICH: Okay. What's the first thing you gotta do for the installation in terms of labor?

DENISE: uh....remove the old toilet?

PERPICH: Right. Detach the 4 anchor bolts, shut the water off, and then detach the supply line. What's next?

DENISE: Get rid of it?

PERPICH: Yeah, and what's involved with that? You might need to get a dumpster. Check with contractors because that's something that may be included in the scope of the contract. Now, after its been removed, you have to remove the wax ring, replace the hub, install a new wax ring if the old one isn't salvageable. Resurface the contact area between the toilet and the bathroom, install the toilet. Now you have to attach the supply line, bolt the toilet to the ground. Install the flush valve because those don't come with the commode. Caulk the base of the toilet where it meets the ground. Buy a toilet seat and any necessary fittings for the valve. Now you have a box for the toilet, a box for the toilet seat, a box for the valve, boxes for the fittings - basically a lot of trash. You gotta get rid of that. Tools you'll need are a sauter iron, grinding wheel, saw, wrenches, and other plumbing tools.

DENISE: Wow. That is...a lot more than I considered in that process. What does this typically cost? We need to be sure that the cost is less than the savings associated with reduced water use.

PERPICH: I gotta go but now that I know what you're after, email me to set a time to get deeper into this.

Appendix A: Interview Transcripts

Interview with Superintendent Cheryl Pedisich and Assistant Superintendent of Business Jeff Carlson of Three Village Central School District in Suffolk County, New York

Q: What is the process for implementing capital projects?

A: Jeff: Each year there are budget presentations we give to the board. Something like utilities – we need to put in what we need. As far as capital construction – that is a challenge for us – the upfront capital cost to do any work in our buildings is a challenge.

Specifically, the Board of Education has a facilities Committee. What we do when we have capital projects that we are considering: we present to the facilities committee.

Q: What are some of the reasons for implementing an energy efficiency or sustainability program in your schools?

It's possible to get money back in the form of building aid for states

If it's something that would save us money, that would be a factor as well

Q: What are some examples of sustainability initiatives your district has undertaken?

A: Jeff: We are in the design stage of an energy services contract – we do work on our buildings, it could be things such as replacing old, inefficient boilers and burners, old lighting fixtures with more energy efficient fixtures; energy savings over a period of years pays for the installation to be done

LED lighting fixtures – by replacing them, the savings on electricity will pay for the work to be done

Cheryl: We started at Ward Melville High School a reusable water bottle campaign, installed fountains with purified water – started as a pilot at Ward Melville High School very successful, going to roll out district wide

Q: Where are some of the major areas of water cost?

A: Jeff: We spent about $35,000 on water district wide. The Vast majority was from bathrooms most likely. We don't have a lot of irrigation district wide in the form of sprinklers; most of water usage is from bathrooms.

Costwise - $35,000 in last school year on total water usage districtwide – don't know what that translates into in gallons – almost all of it is domestic, some would be from Kitchens, not as much as you might think; very little irrigation, landscaping, don't use dishes/silverware/any kind of stuff that needs to be washed, all disposable, most of the savings potential in restroom, toilets, sinks, showers, ect.

Q: What are some of the restrictions or qualifications a sustainability project must surpass to be implemented?

Appendix A: Interview Transcripts

A: Jeff: NYS Department to qualify as an energy performance contract – payback period has to be more than 18 years. We have to save that much in energy savings to get that back in 18 years. We borrow the money to do the work, savings makes those loan periods, has to be paid off in 18 years. We also get a percent back on new construction from the state.

Budget and cost issues: have a tax cap in New York state (one and only issues) can't increase taxes by more than 2 percent or Consumer Price Index, whichever is lower, difficult when we need to deal with contractual salary increase, health insurance, retirement, have needed to cut staff; hard to add new things when we're cutting staff

Q: Are there any discount or hurdle rates a capital project must surpass to be considered?

A: Jeff: No discount or hurdle rate – use current borrowing rates to consider projects

Savings has to show how many lighting fixtures, current cost, what it will be replaced with, projection of savings, all of that gets reviewed by state education department. Johnson Controls is the company that is doing the lighting project, also solar power photovoltaic system hooked up, looking to expand that

Q: What were the steps that lead to choosing Johnson Controls for the energy efficiency project?

Request for proposals, we advertise, interested in companies to do this project, allows them to do a walk through of school.

Q: How would a business pitch a capital project to schools?

A: Jeff: I would meet with them, hear the ideas, might ask other experts in the area about that (state education department – office of facilities planning), talk to superintendent, then bring to Board of Education facilities committee, then present to full Board, and if they like the idea, proceed from there, depending on type of work might need voter approval, might need to be worked into following year's school budget

Q: What is the estimated time of these contracts from pitch to start of work?

A: Jeff: It varies, can be quick, depending on scope, dollar amount, upfront capital investment, voter approval, any kind of capital work done by school needs approval by state education department (anywhere from 6 months to a year to get this approval), after we get this approval, depends on if need to advertise and do bids, and who is paying for what

Upfront capital financing – kind of what we're doing with the LED lighting – same idea, we are paying for the installation of the new lighting fixtures with the savings on the new electricity, already have a similar business model

Q: Is there any educational component to the Johnson Controls project?

A: Cheryl: Johnson controls came and met with students and teachers in classrooms, there is definitely an educational component, they offered it upfront, part of their proposal to us, always appealing from an educational perspective. We are always looking for that educational piece as an incentive.

Appendix A: Interview Transcripts

Marcus Chapman: Canton High School

1. Introduction
    a. Introduce myself and my teammates
    b. Describe our project and the information we are looking to gather in the interview.
2. Kickoff
    a. What is your role in the school district?
        i. Canton Elementary
        ii. Canton High School – 7th through 12
            1. High School Principal, Transportation, Coach, Student Council Sponsor
    b. What would a typical week working in your role consist of?
        i. State reports, teacher evaluations (in class), student discipline, high school football practice, administrator attends all activities (small schools have less bodies to spread the work load over)
3. Build Rapport
    a. What are the biggest concerns currently facing your district?
        i. Poverty levels in town cause attendance levels in school
            1. Correspondingly, expectations are lower for parents and students. This corresponds to Native Americans – no desire to send children to college. Doesn't want to split up the family
    b. How do you view sustainability?
        i. Not addressed as much in smaller schools – not a huge concern. Not viable from a business. Also feels at the mercy of the energy companies.
4. Grand Tour
    a. What are some of the budget and cost issues facing your district?
        i. Manage budget well – don't overspend and are cautious – results in a significant carry over (~$1,000,000 last year)
        ii. Where does budget come from:
            1. percent of property tax (**ad valorem** tax) - millage

2. percent of gross production tax (oil and natural gas) - millage
3. State Department of Education – dictate so much per child; provides the difference
4. Some programs for federal funding: grants, programs, often provided only once (Child nutrition program)

iii. ~ 70 percent to teacher salaries

b. How does budget impact investing decisions?
   i. School board makes decisions based on Superintendent proposal
c. Is there a certain rate of return that new school cost savings programs must attain?
   i. Case-by-case
   ii. Looking bond issue for energy issue – heating cost (gas vs electric)
d. What are some of the energy efficiency initiatives that your schools district is currently pursuing?
   i. Heating renovation – roofing changes
   ii. Only looking to replace efficient replacements when equipment fails: bang for your buck
e. What do you know about water use in your school district?
   i. See excel spreadsheet
   ii. Dishwasher; pre-rinse spray valves;

5. Reflection
   a. Summarize understandings about budget concerns and investment decisions for the school district.
   b. Link personal views on sustainability to energy efficiency initiatives in schools.
6. Wrap-up
   a. Thank you for your time. Are there any other thoughts about budgets, water conservation, energy efficiency, or any other information that you want to bring up?

Appendix A: Interview Transcripts

Rain Bird - Mark Austin

About: Accomplished senior sales manager with over 20 years of consultative and solution sales experience in the Computer Automation and Commercial Irrigation industries. Successful in growing new business, developing customer loyalty and in developing strong relationships with business partners and distributors. Involved in the development and marketing of new products and strategic planning .

Are you able or willing to discuss the site report regarding water savings of 30 percent annually by incorporating a Maxicom Central Controller?

http://www.rainbird.com/documents/turf/site_LittletonPublicSchools-LittletonCO.pdf

Unable to discuss. Did not have the details. Happy to discuss water conservation in irrigation/landscaping usage area. Many school incorporate similar technology.

What are the benefits of smart controllers?

- General rule: Controller 24 to 32 stations w/ comm hardware, central command unit to adjust schedule - $6,000 - 30 to 40% savings.
- IQ system: ~ 1/2 maxicom (~ $2,500 to $3,000 per controller w/ 48 stations)
- Incorporate weather data and often rain sensors.
- Proven effective on golf courses – developed for golf courses
- Could use onsite weather station - ~$10,000
- Additional benefits include ET (evapotransporation), or the amount of water needed to keep a plant healthy.
- Other technology
- 10% to 15% by only adding rain sensor, though ET offers an additional 20 to 30%

Other techniques?

- Manageable allowed depletion: want to irrigate more but less often
- Manage participation in each zone
- Even distribution is key to savings
- New nozzles, filters = more value and allow savings from systems already in the ground
- Intake rate for slopes - cycle soaking - 20 minute wait between cycles - 2 to 5 minutes on run time

Inexpensive Savings Techniques?

- audit
- level heads: ~10% savings
- filters
- new heads
- check seals - where pop up

Thoughts on rainwater harvesting?

- dappled in it - road blocks though high savings potential
- enough rain = feasible

Other suggestions?

Appendix A: Interview Transcripts

DO SOMETHING!

- tune: ~5 to 10%
- audit
- rain sensor: 10 to 15%
- precipitation rate
- controller
- central control
- replace system

Appendix A: Interview Transcripts

Brianna Fairchild - BLUElab:

Background:

Water experience: Engin 100 - Engineers making a difference, gardening, recycling, water catchment; water collection hydroponics

BLUelab: sophomore year, Hagley gap, bio-sand for water improvement

- broadened ideas to catchment, filtration, quality
- hydrology courses and drinking water

Looking to incorporate a grey water system:

- Use: bucket flush toilets - sink water as toilet flushing water
    - No need to treat
    - Sink wastewater piped to sand filter drained to bucket:
    - Chlorine prior transfer to storage tank
- Not used b/c bathroom was not used house

Issues: People not aware of water quality issues; need to acquire chlorine in addition - extra costs; spillage from overflow and monitoring; modifications to household, i.e. under the sink modifications

- Biosand filter: only work with a settling time for micro-organisms to work with the water
    - Maintenance concerns (once/month)
    - Individual knowledge of systems
    - Incorporated technology in an elementary school
    - Water quality has improved
        - Concern for water quality amongst kids: provide clean water
    - Installed smaller systems in a clinic and library
    - Cost: 55 gallon trash can (~$25); pvc piping and glue; sand and gravel from river
        - No maintenance cost

Appendix A: Interview Transcripts

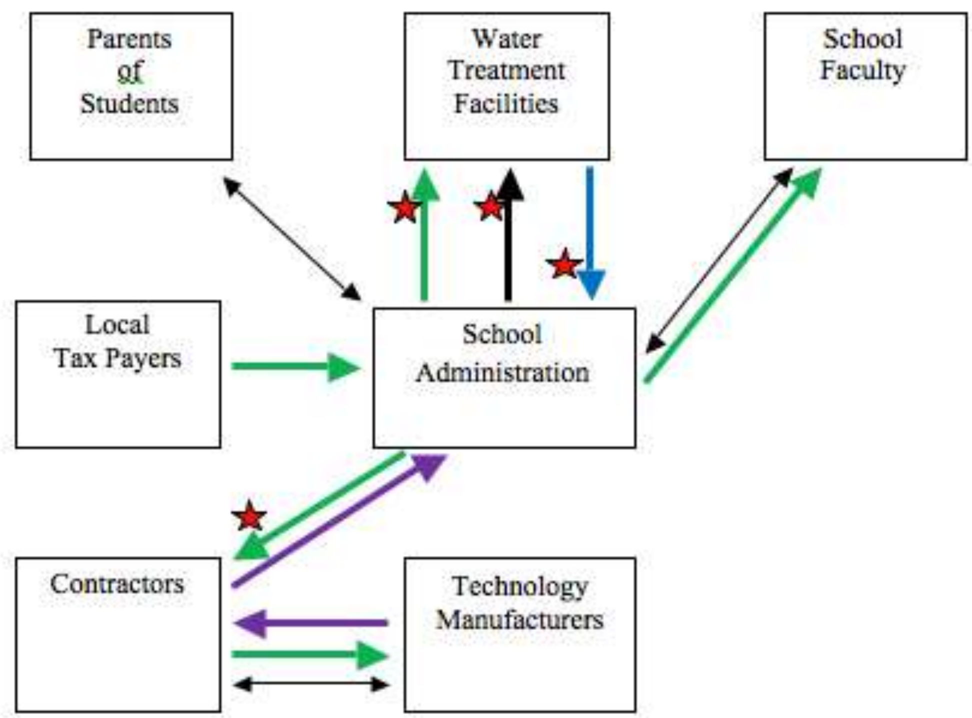
Thoughts on rainwater harvesting?

- Address precip patterns - determine rainy seasons
- Annual precip for volume collection
- Gutters and roofs for collections
- Average monthly collection
- Use ground tank or roof for hydrostatic drive pressure
- First flush systems; eliminate dirty water from initial runoff
- Treatment - determine use

Other thoughts?

- Grey water repurposing has potential to reduce costs (using non-potable water where possible)
- Dishwashing

Appendix B: Stakeholder Network



Single ended arrow: Material Flow
- Green: Money
- Blue: Blue water
- Black: Black water
- Purple: Product

Double arrow: Information Flow

Appendix C: Baseline Evaluation – Water Consumption

Assumptions for Per Use Consumption [15]:

1. Toilets:
    a. 3 uses per day per female occupant
    b. 1 use per day per male occupant
    c. Urinals: 2 uses per day per male occupant
2. Bathroom Faucets: 4 uses per day for 15 seconds per use (though 15 to 60 seconds per use is likely)
3. Showers: 8 minutes per shower for 50% of the athletes

Additionally, calculations only account for usage during school days when students and staff are present. Additional usage is expected for after hour affairs, staff days during the summer, and other summer activities.

Costing estimates where compared to items available on the market and available case studies.

Lakeshore High School's Occupant Breakdown and Operational Days

Total Occupants	1,049
Male Occupants	557
Female Occupants	492
Athletes	120
Days Operating	173

Appendix C: Baseline Evaluation – Water Consumption

Number of Restroom/Domestic Fixtures in Lakeshore High School

Component	**Number of Installs**
Toilet - Female	24
Toilet - Male	13
Urinal - Male	18
Bathroom Faucet	39
Showers	10

End-Use Estimates of Baseline Water Consumption at Lakeshore High School

Expected Annual Consumption	100%	4,726,475 gallons
Domestic/Restroom	45%	2,126,914 gallons
Irrigation/Landscaping	28%	1,323,413 gallons
Cooling and Heating	11%	519,912 gallons
Kitchen/Dishwashing	7%	330,853 gallons
Pools	5%	236,324 gallons
Laundry	3%	141,794 gallons
Other	1%	47,265 gallons

*Estimates of all usage outside Domestic/Restroom was from literature [1].

Appendix D: GHG Emission Tables for Baseline and Upgraded Fixtures

This appendix provides the values used to calculate the baseline and upgraded fixture GHG emissions. Also provided are the resulting GHG emissions of the baseline and upgraded fixtures for a single year. The upgraded fixture GHG emissions include the raw materials and manufacturing (RMM) emissions of the new technology to be installed as well as the end-of-life disposal (EOLD) emissions for the baseline technology. The EOLD of the upgraded fixtures was used in calculating the net GHG emissions over a 20-year lifetime.

Table D-1: Constants used to calculate GHG emissions

Water Supply Energy	1100	kWh/MM gal
Water Treatment Energy	2500	kWh/MM gal
Energy Unit Conversion	0.0036	GJ/kWh
Emissions Factor	0.188	mt CO_2 e-/GJ
Installation Factor	10	% RMM

The overall equation for calculating the emissions associated with annual water use is below:

$$\text{GHGs} = \text{Water Use}\left[\frac{\text{MM gal}}{\text{year}}\right] \times \text{Energy}\left[\frac{\text{kWh}}{\text{MMgal}}\right] \times 0.0036\left[\frac{\text{GJ}}{\text{kWh}}\right] \times 0.188\left[\frac{\text{mt CO}_2\text{ e} -}{\text{GJ}}\right]$$

Appendix D: GHG Emission Tables for Baseline and Upgraded Fixtures

Table D-2: GHG emission results for toilets

Toilets (Baseline)			**Toilets (Upgraded)**		
Quantity	37		Quantity	37	
RMM/unit	N/A		RMM/unit	0.091	mt CO_2 e-
EOLD/unit	0.005	mt CO_2 e-	EOLD/unit	0.005	mt CO_2 e-
Functional Unit Use	3.5	gal/flush	Functional Unit Use	1.1	gal/flush
Annual water use	1.230982	MM gal	Annual water use	0.38688	MM gal
Shipping Weight	65.5	lbs	Shipping Weight	65.5	lbs
RMM Emissions	N/A		RMM Emissions	3.367	mt CO_2 e-
EOLD Emissions	0.185	mt CO_2 e-	EOLD Emissions	0.185	mt CO_2 e-
Supply Emissions	0.916441	mt CO_2 e-	Supply Emissions	0.288024	mt CO_2 e-
Treatment Emissions	2.082821	mt CO_2 e-	Treatment Emissions	0.654601	mt CO_2 e-
Installation	N/A	mt CO_2 e-	Installation	0.3367	mt CO_2 e-
Total Use Emissions	2.999262	mt CO_2 e-	Total Use Emissions	0.942625	mt CO_2 e-

Table D-3: GHG emission results for urinals

Urinals (Baseline)			**Urinals (Upgraded)**		
Quantity	18		Quantity	18	
RMM/unit	N/A		RMM/unit	0.058351	mt CO_2 e-
EOLD/unit	0.003206	mt CO_2 e-	EOLD/unit	0.003206	mt CO_2 e-
Functional Unit Use	1.5	gal/flush	Functional Unit Use	0.13	gal/flush
Annual water use	0.289083	MM gal	Annual water use	0.02409	MM gal
Shipping Weight	42	lbs	Shipping Weight	42	lbs
RMM Emissions	N/A		RMM Emissions	1.050321	mt CO_2 e-
EOLD Emissions	0.05771	mt CO_2 e-	EOLD Emissions	0.05771	mt CO_2 e-
Supply Emissions	0.215217	mt CO_2 e-	Supply Emissions	0.017935	mt CO_2 e-
Treatment Emissions	0.489128	mt CO_2 e-	Treatment Emissions	0.040761	mt CO_2 e-
Installation	N/A	mt CO_2 e-	Installation	0.105032	mt CO_2 e-
Total Use Emissions	0.704345	mt CO_2 e-	Total Use Emissions	0.058695	mt CO_2 e-

Appendix D: GHG Emission Tables for Baseline and Upgraded Fixtures

Table D-4: GHG emission results for faucets

Faucets (Baseline)			**Faucets (Upgraded)**		
Quantity	39		Quantity	39	
RMM/unit	N/A		RMM/unit	0.01	mt CO_2 e-
EOLD/unit	0	mt CO_2 e-	EOLD/unit	0	mt CO_2 e-
Functional Unit Use	2.2	gal/15 sec	Functional Unit Use	0.5	gal/15 sec
Annual water use	0.399249	MM gal	Annual water use	0.090739	MM gal
Shipping Weight	N/A	lbs	Shipping Weight	N/A	lbs
RMM Emissions	N/A		RMM Emissions	0.39	mt CO_2 e-
EOLD Emissions	0	mt CO_2 e-	EOLD Emissions	0	mt CO_2 e-
Supply Emissions	0.297233	mt CO_2 e-	Supply Emissions	0.067553	mt CO_2 e-
Treatment Emissions	0.675529	mt CO_2 e-	Treatment Emissions	0.15353	mt CO_2 e-
Installation	N/A	mt CO_2 e-	Installation	0.039	mt CO_2 e-
Total Use Emissions	0.972762	mt CO_2 e-	Total Use Emissions	0.221084	mt CO_2 e-

Table D-5: GHG emission results for showerheads

Showerhead (Baseline)			**Showerhead (Upgraded)**		
Quantity	10		Quantity	10	
RMM/unit	N/A		RMM/unit	0.01	mt CO_2 e-
EOLD/unit	0	mt CO_2 e-	EOLD/unit	0	mt CO_2 e-
Functional Unit Use	2.5	gal/8 min	Functional Unit Use	1.5	gal/8 min
Annual water use	0.2076	MM gal	Annual water use	0.12456	MM gal
Shipping Weight	N/A	lbs	Shipping Weight	N/A	lbs
RMM Emissions	N/A		RMM Emissions	0.1	mt CO_2 e-
EOLD Emissions	0	mt CO_2 e-	EOLD Emissions	0	mt CO_2 e-
Supply Emissions	0.154554	mt CO_2 e-	Supply Emissions	0.092732	mt CO_2 e-
Treatment Emissions	0.351259	mt CO_2 e-	Treatment Emissions	0.210756	mt CO_2 e-
Installation	N/A	mt CO_2 e-	Installation	0.01	mt CO_2 e-
Total Use Emissions	0.505813	mt CO_2 e-	Total Use Emissions	0.303488	mt CO_2 e-

Appendix D: GHG Emission Tables for Baseline and Upgraded Fixtures

Table D-6: Total GHG emissions across all fixtures

Baseline: Annual emissions from water use	5.182182	mt CO2 e-
Upgrade: Annual emissions from water use	1.525892	mt CO2 e-
Annual reduction of emissions from water use	3.65629	mt CO_2 e-
Emissions due to retrofitting	5.640763	mt CO_2 e-

Appendix E: Rainwater Harvesting Evaluation

This appendix provides the evaluation of installing a rainwater harvesting system. Water usage data is based on Lakeshore High School in Stevensville, MI. Reduction in toilet water results in a new, annual toilet consumption of 386,880 gallons a year is based on the number of schools day per year: 173 days.

The size of the harvesting tank was selected to provide one day's worth of toilet water. If more than a day of toilet water was to be provided by rainwater harvesting, the tank would be quite large and difficult to install on a land parcel that is already built upon.

Toilet water consumption per day:

$$386{,}880\ \frac{gallons}{year} \times \frac{1\ year}{173\ days} = 2{,}236.3\frac{gallons}{day}$$

Rounding up to the nearest 500 hundred mark, the tank size to be evaluated is 2,500 gallons.

Using an equation from literature [20] that estimates the maximum rainwater to be collected in a month based on the surface area of the roof and the average monthly rainfall, the expected time to collect 2,500 gallons is calculated below. Google Earth and the scale provided, was used to estimate the roof area of Lakeshore High School in Stevensville, MI. The average monthly rainfall is that of Atlanta, GA and is taken from a rainwater handbook [20].

$$V\left(\frac{gallons}{month}\right) = \ 0.5\ \times roof\ surface\ area\ (ft^2) \times average\ monthly\ rainfall\ \text{(inches)}$$

$$0.5\ \times 193{,}750\ (ft^2) \times 3\ inches = 290{,}625\ \frac{gallons}{month}$$

Assuming one month has an average of 30 days, the amount of water that can theoretically be collected in a day is calculated below:

$$290{,}625\ \frac{gallons}{month} \times \frac{1\ month}{30\ days} = \ 9{,}688\ \frac{gallons}{day}$$

Because 2,500 gallons is less than 9,688 gallons, it should theoretically take less than a day to fill up the harvesting tank. However, accounting for the reality of lapses in rainfall, a 5 day fill up time will be assumed for further calculations. This means that the total cycle of the rainwater harvest system is approximately 6 days: 5 days for tank fill up and 1 day to empty the tank. The number of cycles per year is calculated below:

$$173\ \frac{days}{year} \times \frac{1\ cycle}{6\ days} = 28.83\ \frac{cycles}{year}$$

The 28.83 cycles per year will be rounded down to 28 in order to perform a conservative evaluation of rainwater harvesting systems. The amount of water saved per year is calculated below:

$$28\ \frac{cycles}{year} \times 2{,}500\ \frac{gallons}{cycle} = 70,000\ \frac{gallons}{year}$$

The estimated annual monetary savings of this rainwater harvesting system based on Atlanta water cost is:

$$70,000\ \frac{gallons}{year} \times \frac{\$30}{1000\ gallons} = \frac{\$2{,}100}{year}$$

The cost of the 2,500 gallon system is based on the assumption that it will be installed underground. Based on data searches, an underground, plastic cistern sized for 1,700 gallons is estimated to cost $12,000 [21]. Therefore a 2,500 gallon system can be priced using the following calculation:

$$2{,}500\ gallons \times \frac{\$12000}{1{,}700\ gallons} = \$17{,}647.05$$

Now, the simple payback of the 2,500 gallon rainwater harvesting system can be evaluated:

$$\$17{,}647.05\ \times \frac{1\ year}{\$2{,}100} = 8.40\ years$$

The simple payback is roughly 8.5 years. This number should be lower if depreciation is taken into account. Also, it is likely that the actual cost of the system will be higher than predicted. Overall, the payback period of the rainwater harvesting system is at least 8.5 years, which does not meet our project requirements and specifications.

Appendix F: Comparison of Baseline GHG Emissions to Alpha Design

This appendix provides the cumulative GHG emissions over a 20-year lifetime for the baseline and the alpha design for each of the following restroom fixtures: toilets, urinals, faucets, and showerheads. Included in the baseline cumulative emissions is the disposal of the fixtures after 20 years. Included in the cumulative emissions of the upgraded fixtures are the emissions associated with the production of the new fixtures at year zero, the disposal of the old fixtures at year zero, and the disposal of the upgraded fixtures at year 20.

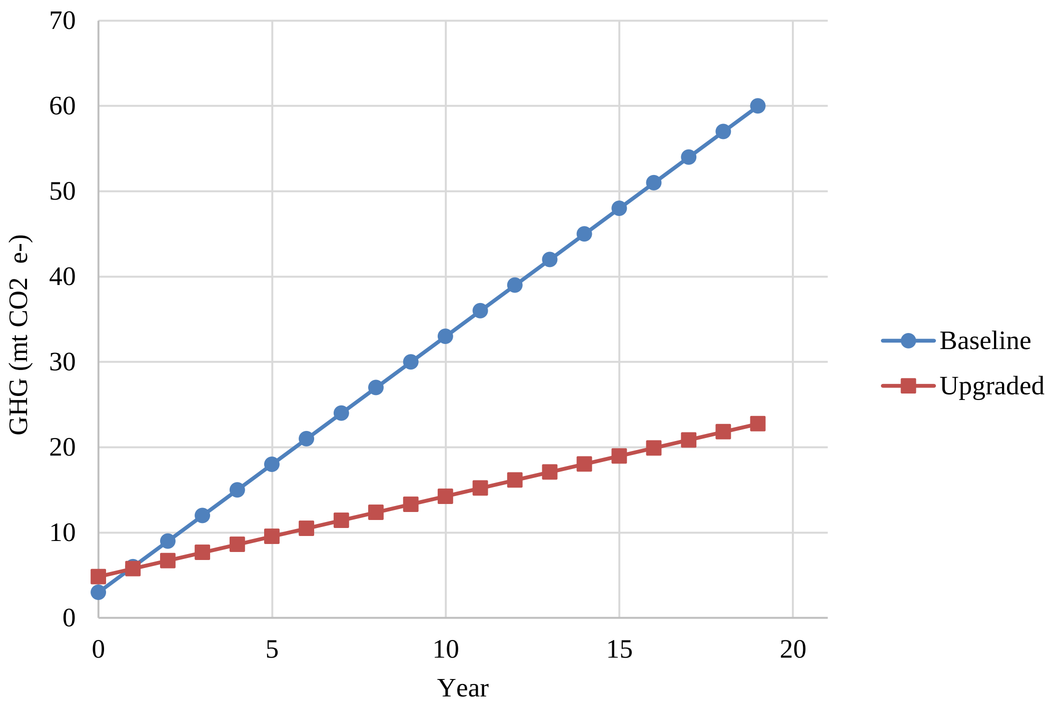


Figure E-1: Cumulative GHG emissions of toilets over 20 years

Appendix F: Comparison of Baseline GHG Emissions to Alpha Design

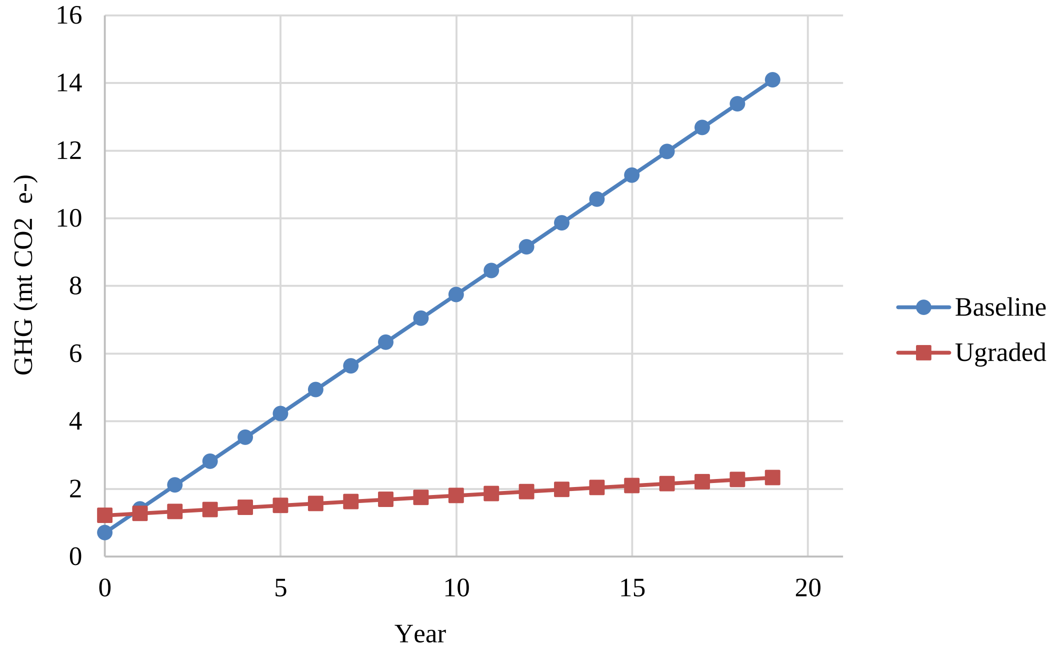


Figure E-2: Cumulative GHG emissions of urinals over 20 years

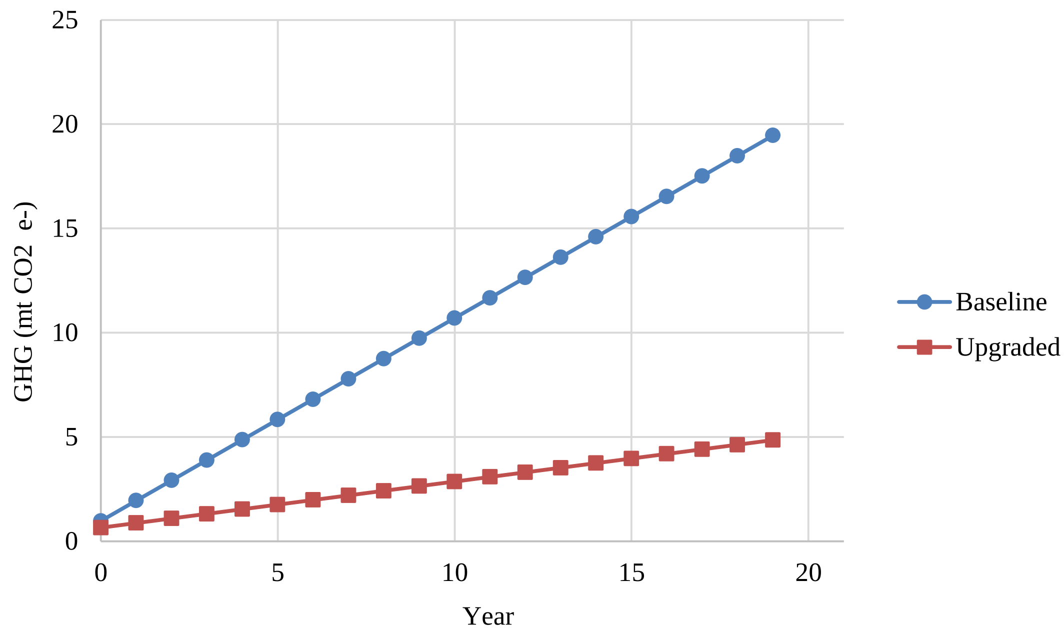


Figure E-3: Cumulative GHG emissions of faucets over 20 years

Appendix F: Comparison of Baseline GHG Emissions to Alpha Design

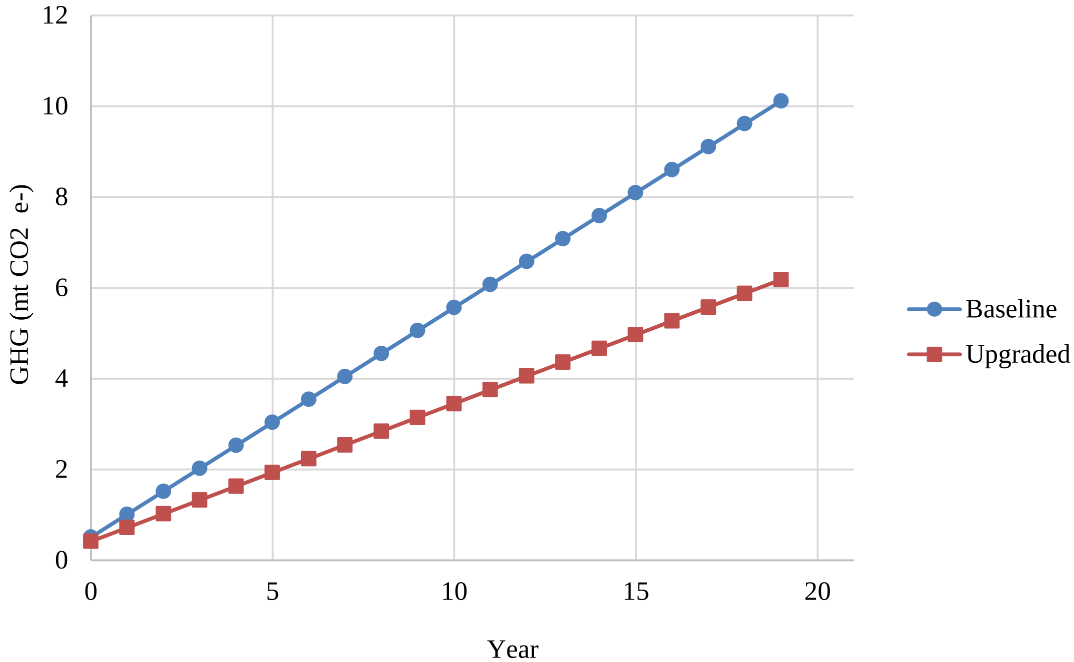


Figure E-4: Cumulative GHG emissions of showerheads over 20 years

Appendix G: Target Market

Table F-1: Cities with the Highest Water Cost:

City	State	Water Cost
San Jose	CA	$2.95 / 1000 Gallons
Atlanta	GA	$30/ 1000 Gallons
Seattle	WA	$14.20 /1000 Gallons
Portland	OR	$4.60/ 1000 Gallons
New York	NY	$12.39/ 1000 Gallons
Santa Fe	NM	$21.72 / 1000 Gallons

Table F-2: Number of Schools in Top Three Target Markets

	Atlanta [A]	**Seattle [B]**	**San Jose [C]**
High School	14	14	27
Middle School	15	19	8
Elementary	50	58	8
TOTAL	**79**	**91**	**43**

Table F-3: Market Penetration

	Atlanta [A]	**Seattle [B]**	**San Jose [C]**
5%	4	5	2
10%	8	9	4
25%	20	23	11
TARGET: 50%	**40**	**46**	**22**

[A] Source: http://www.atlantapublicschools.us/cms/lib/GA01000924/Centricity/Domain/1/2013-2014%20School%20List.8.01.13.pdf

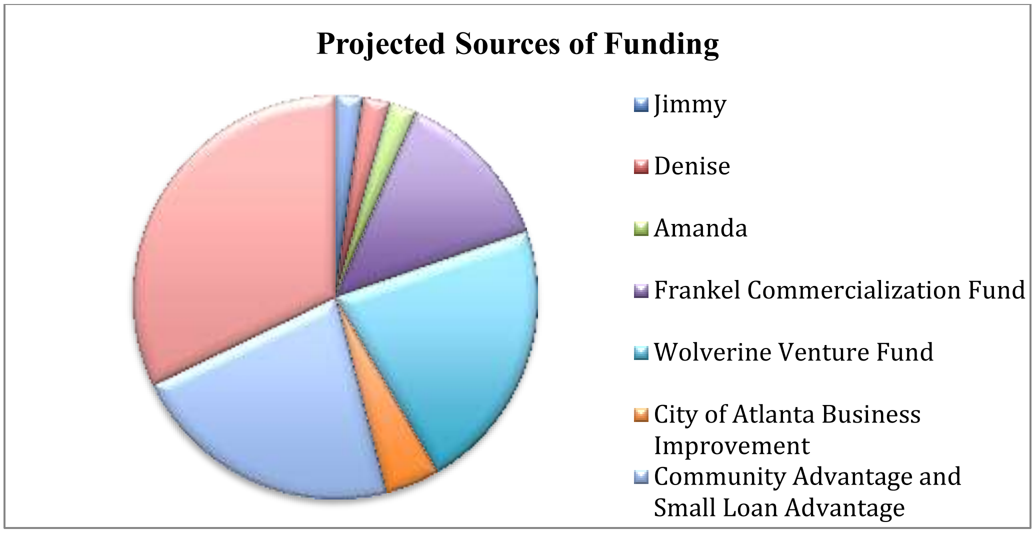
[B] Source: http://www.seattleschools.org/modules/cms/pages.phtml?pageid=197023&sessionid=ae950a22045d9cea17bb5e88a6628bfb&t

[C] Source: http://www.sjusd.org/schools/instruction/downloads/Schools_Addresses.pdf

Appendix H: Start Up Costs

Start Up Costs			Financing	
Brochures	$	120	**Owner/Friends/Family Contributions**	
Deposits - Utilities, Telephone, Internet		200	Jimmy	5,000
Furniture and Fixtures		2,000	Denise	5,000
Insurance		600	Amanda	5,000
Licenses and Permits		500	**Total Private Contributions**	**15,000**
Office Supplies		2,000		
Professional Fees (Legal, Accounting)		2,500	**Venture Capital**	
Remodeling/Cleaning		1,000	Frankel Commercialization Fund	**30,000**
Rent - Down Payments		1,450	Wolverine Venture Fund	**50,000**
Signs		900	**Total Equity Financing**	**95,000**
Trade Shows		240		
Website Design		1,000	**Small Business Loans**	
Estimated Start Up Capital Required		**12,510**	City of Atlanta Business Improvement	10,000
			Community Advantage and Small Loan Advantage	50,000
Cash requirements for two years of expenses - Avg Case		228,446	SBA Microloan Program	73,446
Total Funding Required		**228,446**	**Total Debt Financing**	**133,446**

Appendix H: Start Up Costs



Appendix I: Payback Period of Selected Restroom Technology

	Cost	Current Annual Water Use	Annual Water Cost [A]	% Savings	Water Use	Updated Costs	Number of Installations	Savings/Year
Toilets	$250 - $700	386,880	11,606	68.57%	121,591	3,648	37	7,958.67
Urinals	$250 - $700	24,090	723	91.67%	2,008	60	11	662.48
Faucets	$3 -$10	181,477	5,444	77.27%	41,245	1,237	28	4,206.97
Showerheads	$ 30	124,560	3,737	40.00%	74,736	2,242	13	1,494.72
		717,007	**$ 21,510**		**239,579**	**$ 7,187**		

Best Case [B]			**Investment**	**Savings**
	NPV	**IRR**	**Year 0**	**Years 1 - 20**
Toilets	58,507	86%	(9,250)	7,959
Urinals	2,890	23%	(2,750)	662
Faucets	35,732	5008%	(84)	4,207
Showerheads	12,335	383%	(390)	1,495

Worst Case			**Investment**	**Savings**
	NPV	**IRR**	**Year 0**	**Years 1 - 20**
Toilets	34,634	30%	(25,900)	7,959
Urinals	(2,661)	3%	(7,700)	662
Faucets	27,045	1502%	(280)	4,207
Showerheads	9,318	383%	(390)	1,495

	Best Case Cost	Worst Case Costs
Toilets	$ 250	$ 700
Urinals	$ 250	$ 700
Faucets	$ 3	$ 10
Showerheads	$ 30	$ 30

[A] Annual water cost calculated using Atlanta rates of $30 per 1000 gallons

[B] Best Case assumes lowest installation cost for technology, while Worst Case assumes highest:

Appendix J: Revenue Calculation per Installation

	Best Case	Average	Worst Case
Cost of Installed Machinery [A]	$ 12,474	$ 24,530	$ 34,270
Total Savings Per Year	$ 14,323	$ 14,323	$ 14,323
Percentage of Savings Collected	80%	75%	50%
Yearly Revenue Per School B	$ 11,458.27	$ 10,742.13	$ 7,161.42
Payback Period Per System	1.09	2.28	4.79
5 Year Savings Collected	$ 57,291.36	$ 53,710.65	$ 35,807.10
Undiscounted Profit	$ 44,817.36	$ 29,180.65	$ 1,537.10
Discounted Profit [C]	$ 35,366.02	$ 20,931.24	$ (3,109.33)

[A] We are assuming different costs driven by differences in installation costs

	Best Case	Average	Worst Case
Toilets	$ 250	$ 500	$ 700
Urinals	$ 250	$ 500	$ 700
Faucets	$ 3	$ 5	$ 10
Showerheads	$ 30	$ 30	$ 30

[B] The actual savings collection will likely operate on a case by case basis, driven by contract negotiations with each specific school.

[C] Assume 5% Discount Rate

Appendix K: Projected Installations for all Cases

	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Total Projected Installations**
Atlanta Installations		1	4	15	20				**40**
Seattle Installations				1	8	14	23		**46**
San Jose Installations					1	3	6	11	**22**
Location #4 TBD						1	4	15	**20**
Location #5 TBD							1	4	**5**
Projected Installations	**0**	**1**	**4**	**16**	**29**	**18**	**35**	**30**	**132**

Appendix L: Projected Income Statement – Best Case

Sales Revenue	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**
Revenue from New Installations	10,742	42,969	171,874	311,522	193,358	375,975	322,264
Revenue from Previous Year Installations	-	10,742	53,711	225,585	537,107	719,723	1,052,729
Total Revenue	10,742	53,711	225,585	537,107	730,465	1,095,697	1,374,993
Cost of Sales							
Prorated New Installed Equipment [A]	4,933	19,730	78,920	143,043	88,785	172,638	147,975
Prorated Previously Installed Equipment	-	4,933	24,663	98,650	221,963	231,828	261,423
Construction Labor [B]	30,800	30,800	92,400	123,200	123,200	123,200	123,200
Total Cost of Installation	35,733	55,463	195,983	364,893	433,948	527,665	532,598
Gross Margin	**(24,990)**	**(1,752)**	**29,602**	**172,214**	**296,517**	**568,032**	**842,395**
Operating Expenses							
Sales and Marketing							
Advertising, Brocures, Fliers	1,020	1,020	2,040	3,060	2,040	2,040	2,040
Trade Show Advertisements	480	480	480	480	480	480	480
Direct Sales Force Salaries [D]	30,000	30,000	45,000	60,000	90,000	120,000	120,000
Licenses							
Technology Licenses	500	500	500	500	500	500	500
Legal Fees	500	500	500	500	500	500	500
General & Administrative							
Office Rent [C]	8,700	8,700	8,700	8,700	8,700	8,700	8,700
Utilities	400	400	400	600	600	800	800
Telephone/Internet	1,080	1,080	1,080	1,080	1,080	1,080	1,080
Admin salaries	15,000	15,000	15,000	15,000	30,000	30,000	30,000
Supplies	500	500	500	500	1,000	1,000	1,000
Insurance	600	600	600	600	600	600	600
Owner Salaries [E]	40,000	40,000	60,000	120,000	150,000	150,000	150,000
Total Operating Expenses	**98,780**	**98,780**	**134,800**	**211,020**	**285,500**	**315,700**	**315,700**
EBIT	(123,770)	(100,532)	(105,198)	(38,806)	11,017	252,332	526,695
Interest	24,134	24,134	24,134	24,134	24,134	24,134	24,134
Taxes [F]	-	-	-	-	-	7,984	226,352
Net Income	**(147,904)**	**(124,666)**	**(129,332)**	**(62,940)**	**(13,116)**	**220,215**	**276,209**

Appendix M: Projected Income Statement – Average Case

Sales Revenue	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**
Revenue from New Installations	7,161	28,646	114,583	207,681	128,906	250,650	214,843
Revenue from Previous Year Installations	-	7,161	35,807	150,390	358,071	479,815	701,819
Total Revenue	7,161	35,807	150,390	358,071	486,977	730,465	916,662
Cost of Sales							
Prorated New Installed Equipment [A]	8,568	34,270	137,080	248,458	154,215	299,863	257,025
Prorated Previously Installed Equipment	-	8,568	42,838	171,350	385,538	402,673	454,078
Construction Labor [B]	30,800	30,800	92,400	123,200	123,200	123,200	123,200
Total Cost of Installation	39,368	73,638	272,318	543,008	662,953	825,735	834,303
Gross Margin	**(32,206)**	**(37,830)**	**(121,928)**	**(184,936)**	**(175,976)**	**(95,270)**	**82,359**
Operating Expenses							
Sales and Marketing							
Advertising, Brocures, Fliers	1,020	1,020	2,040	3,060	2,040	2,040	2,040
Trade Show Advertisements	480	480	480	480	480	480	480
Direct Sales Force Salaries [D]	30,000	30,000	45,000	60,000	90,000	120,000	120,000
Licenses							
Technology Licenses	500	500	500	500	500	500	500
Legal Fees	500	500	500	500	500	500	500
General & Administrative							
Office Rent [C]	8,700	8,700	8,700	8,700	8,700	8,700	8,700
Utilities	400	400	400	600	600	800	800
Telephone/Internet	1,080	1,080	1,080	1,080	1,080	1,080	1,080
Admin salaries	15,000	15,000	15,000	15,000	30,000	30,000	30,000
Supplies	500	500	500	500	1,000	1,000	1,000
Insurance	600	600	600	600	600	600	600
Owner Salaries [E]	40,000	40,000	60,000	120,000	150,000	150,000	150,000
Total Operating Expenses	**98,780**	**98,780**	**134,800**	**211,020**	**285,500**	**315,700**	**315,700**
EBIT	(130,986)	(136,610)	(256,728)	(395,956)	(461,476)	(410,970)	(233,341)
Interest	24,134	24,134	24,134	24,134	24,134	24,134	24,134
Taxes [F]	-	-	-	-	-	-	-
Net Income	**(155,120)**	**(160,744)**	**(280,861)**	**(420,090)**	**(485,610)**	**(435,104)**	**(257,474)**

Appendix N: Projected Income Statement – Worst Case

Sales Revenue	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**
Revenue from New Installations	7,161	28,646	114,583	207,681	128,906	250,650	214,843
Revenue from Previous Year Installations	-	7,161	35,807	150,390	358,071	479,815	701,819
Total Revenue	7,161	35,807	150,390	358,071	486,977	730,465	916,662
Cost of Sales							
Prorated New Installed Equipment [A]	8,568	34,270	137,080	248,458	154,215	299,863	257,025
Prorated Previously Installed Equipment	-	8,568	42,838	171,350	385,538	402,673	454,078
Construction Labor [B]	30,800	30,800	92,400	123,200	123,200	123,200	123,200
Total Cost of Installation	39,368	73,638	272,318	543,008	662,953	825,735	834,303
Gross Margin	**(32,206)**	**(37,830)**	**(121,928)**	**(184,936)**	**(175,976)**	**(95,270)**	**82,359**
Operating Expenses							
Sales and Marketing							
Advertising, Brocures, Fliers	1,020	1,020	2,040	3,060	2,040	2,040	2,040
Trade Show Advertisements	480	480	480	480	480	480	480
Direct Sales Force Salaries [D]	30,000	30,000	45,000	60,000	90,000	120,000	120,000
Licenses							
Technology Licenses	500	500	500	500	500	500	500
Legal Fees	500	500	500	500	500	500	500
General & Administrative							
Office Rent [C]	8,700	8,700	8,700	8,700	8,700	8,700	8,700
Utilities	400	400	400	600	600	800	800
Telephone/Internet	1,080	1,080	1,080	1,080	1,080	1,080	1,080
Admin salaries	15,000	15,000	15,000	15,000	30,000	30,000	30,000
Supplies	500	500	500	500	1,000	1,000	1,000
Insurance	600	600	600	600	600	600	600
Owner Salaries [E]	40,000	40,000	60,000	120,000	150,000	150,000	150,000
Total Operating Expenses	**98,780**	**98,780**	**134,800**	**211,020**	**285,500**	**315,700**	**315,700**
EBIT	(130,986)	(136,610)	(256,728)	(395,956)	(461,476)	(410,970)	(233,341)
Interest	24,134	24,134	24,134	24,134	24,134	24,134	24,134
Taxes [F]	-	-	-	-	-	-	-
Net Income	**(155,120)**	**(160,744)**	**(280,861)**	**(420,090)**	**(485,610)**	**(435,104)**	**(257,474)**

Appendix O: Assumptions for Revenue and Cost Calculations

[A] Installed equipment includes low flow faucets, low flush toilets and urinals, and low flow showerheads.

[B] One construction foreman per 5 installs, with at least one for each geographic area. Assuming yearly base salary of $77,000 plus 20% for benefits, prorated over 4 month installation period.

http://www.indeed.com/salary/q-Construction-Superintendent-l
Atlanta,-GA.html

[C] Assuming our corporate headquarters will be located in Atlanta, GA. Based on actual advertised rent: http://atlanta.craigslist.org/atl/off/4223656774.html

[D] Assume direct salesman salary of $50,000, plus 20% for benefits, with the following employment schedule:

	Salesman 1	Salesman 2
Year 1	50%	
Year 2	50%	
Year 3	75%	
Year 4	100%	
Year 5	100%	1
Year 6	100%	1
Year 7	100%	1

http://www.indeed.com/salary/q-Sales-Representative-l-Atlanta,-
GA.html

[E] Owner salaries will be a base of $40,000 each for the first 3 years, prorated by the number of months the business will be completing installations. We are operating under the assumption that this business will be operating on a part time basis until we reach full capacity in year 4.

[F] Utilize previously generated losses in years 4 and 5 to reduce tax burden.

Appendix O: Assumptions for Revenue and Cost Calculations

We are assuming that we will need one full time construction Foreman for every 5 installations, with at least one for each geographic area we are operating in. Initially, the construction work will mainly be completed in the summer when school is not in session. We are operating under the assumption that we can hire hourly construction labor to complete the majority of the work, while maintaining one salaried season construction foreman for every 5 installs to provide oversight and instruction. We will also be employing a direct sales force, with salaried workers. We will begin with one part time employee, and scale up from there as we increase our targeted market penetration.

Appendix P: Statement of Cash Flows for all Cases

Best Case

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Cash Inflows	-	-	-	-	-	-	-
Installation Revenue	11,458	57,291	240,624	572,914	779,163	1,168,744	1,466,659
Cash Outflows	-	-	-	-	-	-	-
Installation Costs	3,119	12,474	49,896	90,437	56,133	109,148	93,555
Operating Expenses	98,780	98,780	134,800	211,020	285,500	315,700	315,700
Interest	24,134	24,134	24,134	24,134	24,134	24,134	24,134
Taxes	-	-	-	-	8,191	202,027	418,663
Total Cash Outflow	126,032	135,388	208,830	325,590	373,958	651,008	852,052
Net Cash Flow	**(114,574)**	**(78,096)**	**31,794**	**247,323**	**405,205**	**517,736**	**614,607**

Average Case

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Cash Inflows	-	-	-	-	-	-	-
Installation Revenue	10,742	53,711	225,585	537,107	730,465	1,095,697	1,374,993
Cash Outflows	-	-	-	-	-	-	-
Installation Costs	14,798	59,190	236,760	429,128	266,355	517,913	443,925
Operating Expenses	98,780	98,780	134,800	211,020	285,500	315,700	315,700
Interest	24,134	24,134	24,134	24,134	24,134	24,134	24,134
Taxes	-	-	-	-	-	7,984	226,352
Total Cash Outflow	137,711	182,104	395,694	664,281	575,989	865,730	1,010,111
Net Cash Flow	**(126,969)**	**(128,393)**	**(170,109)**	**(127,175)**	**154,476**	**229,967**	**364,882**

Worst Case

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Cash Inflows	-	-	-	-	-	-	-
Installation Revenue	7,161	35,807	150,390	358,071	486,977	730,465	916,662
Cash Outflows	-	-	-	-	-	-	-
Installation Costs	25,703	102,810	411,240	745,373	462,645	899,588	771,075
Operating Expenses	98,780	98,780	134,800	211,020	285,500	315,700	315,700
Interest	24,134	24,134	24,134	24,134	24,134	24,134	24,134
Taxes	-	-	-	-	-	-	-
Total Cash Outflow	148,616	225,724	570,174	980,526	772,279	1,239,421	1,110,909
Net Cash Flow	**(141,455)**	**(189,917)**	**(419,784)**	**(622,455)**	**(285,302)**	**(508,956)**	**(194,247)**