DontFlushMe

Connecting people to their water

By

Leif Percifield

Thesis Instructor: Marko Tandefelt
Thesis Writing Instructor: Loretta J. Wolozin

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Abstract

DontFlushMe encourages citizens of New York to conserve water at critical times to increase the overall health of local waterways. Through a network of custom built sensors, readily accessible communication tools and internet-connected visualization devices, residents can be kept informed about the realtime status of the NYC sewer system. The public can then use this information to make informed decisions about their water use which can directly impact local water quality. *DontFlushMe* aims to increase the community's level of awareness, knowledge, and sense of value towards the environment which can result in positive attitudinal and behavioral changes.

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A. Concept and Design Questions

DontFlushMe encourages citizens of New York to conserve water at critical times to increase the overall health of local waterways. Through a network of custom built sensors, readily accessible communication tools and internet-connected visualization devices, residents can be kept informed about the realtime status of the NYC sewer system. The public can then use this information to make informed decisions about their water use which can directly impact local water quality. *DontFlushMe* aims to increase the community's level of awareness, knowledge, and sense of value towards the environment which can result in positive attitudinal and behavioral changes.

Can small scale technological interventions act as a leverage point to inject change in a complex system and at the same time provide a person with enough support to individually engage in conservation efforts, which only succeed when contributed to by communities as a whole?

DontFlushMe aims to create direct positive actions targeted towards increasing the water quality in New York's harbor. Overflow from the city's combined sewer system is the number one source of water pollution. The only "perfect" solution to this problem would require a complete system replacement which is impossibly impractical. *DontFlushMe* is a project developed to directly reduce this pollution by raising awareness and creating leveraged direct action.

Low cost, open-source sensors will be deployed at critical areas throughout the city. These sensors detect when the sewer system overflows and create alerts via twitter, text message and dedicated devices. These alerts encourage targeted reduction

in water consumption, such as a shorter shower or delayed laundry cycle. Alerts also provide recreation users with location specific water quality information to allow more informed decisions to be made regarding direct water contact.

When multiplied, these small scale personal interventions have the ability to greatly impact a large system. For each gallon of water conserved an extra gallon of combined sewage could be treated and therefore not released into the harbor. Admittedly, even if fully adopted throughout the city, *DontFlushMe* could never completely eliminate combined sewer overflows in New York but seeks to encourage a sense of personal responsibility for a system usually overlooked. *DontFlushMe* targets one possible leverage point in an immensely complex system where a multiplicity to interventions are needed and currently being implemented.

DontFlushMe has garnered a good deal of press. The project has beed covered by the BBC[14], Huffington Post[23] and on a variety of blogs including New York Times - Bits[8], Grist[12], Inhabitat[35], Mother Nature Network[10], Change Observer[28] and Pachube[1]. The success in gaining press coverage has encouraged readers to investigate the problem of sewer overflow events, which is a main goal of the project. Plans in motion for the future push to broaden this engagement and support targeted direct action.

B. Impetus

DontFlushMe aims to connect residents to their city's wastewater infrastructure to encourage water conservation and provide an understanding of a complex and hidden public utility. Conservation has become an integral part of many peoples lives. People feel empowered to make a choice that might reduce their impact on the environment

and other people. *DontFlushMe* raises awareness of the impacts that a sewage system has on local waterways to allow different user groups to make informed decisions. Boaters and swimmers will be alerted to water conditions that are undesirable for recreation.

Growing up in Atlanta I saw the city explode in size. From the time I was ten, till my twentieth birthday the city grew by 2 million residents. This rapid growth played havoc with the cities infrastructure. Because of this, Atlanta is now know for its traffic and smog. Atlanta also ran into trouble with its sewer system. The massive population growth and accompanied development meant that the cities wastewater treatment system was unable to handle the demand. This demand was met through un-permitted discharge of untreated wastewater into the Chattahoochee river (figure 1), a source of drinking water for many cities down stream. At one point in the 1990s, Atlanta was paying $7 million a year in pollution fines.[30]

After living in Atlanta, I moved to Las Vegas, New Mexico, a small town in the north eastern part of the state. Water in the desert south west is a critical commodity and is protected fiercely. At times through out the

Figure 1. The author with his sister, Lara Percifield, canoeing in the Chattahoochee River outside of Atlanta

summer the city would completely close car washes, restrict laundromats to be open every other day, and send an alert notice with you bill that detailed the exact number of days drinking water would be available.

The first week I was living in New York, to begin graduate school, I noticed the water use patterns in the city were much different than I was used to. Watching people wash the side walk with drinking water seemed appalling to me. After living in NYC for a little while I also became interested in how the city got water to all its residents and how it carried away all the sewage. Interest in the sewage system peaked after beginning a project on the Gowanus canal.

The creation of *DontFlushMe* stemmed from this curiosity about the NYC infrastructure and a desire to create a DIY technique designed to encourage awareness and conservation. The idea that we all can, and must, contribute in conservation efforts is a driving force behind the project. Gernot Wagner disputes this claim in an op-ed article in the New York Times titled *Going Green but Getting Nowhere*[32]. While Wagner's argument is directed mostly towards carbon emissions, his statements target environmental movements across the board. His main argument is that bottom up efforts do much less than top down "regulatory system" level conservation movements. *DontFlushMe* aims to bridge this gap by providing information that could be considered top down to both citizens and municipalities and allowing for stewardship from all parties.

The DIY/open-source hardware movement has empowered a new cadre of "makers" with the ability to create practical and meaningful technology. One reason for

this growth is due to the development of the Arduino microcontroller platform (Figure 2). The relative ease with which these devices can be created grants new forms of expression and capabilities to lay-people. This allows for a shift of what it means to be “an expert”. This fits into a greater movement called “civic science” where everyday people are empowered to create tools to collect data that was once relegated to university and government researchers. This desire to empower and enable is a driving force behind *DontFlushMe*.

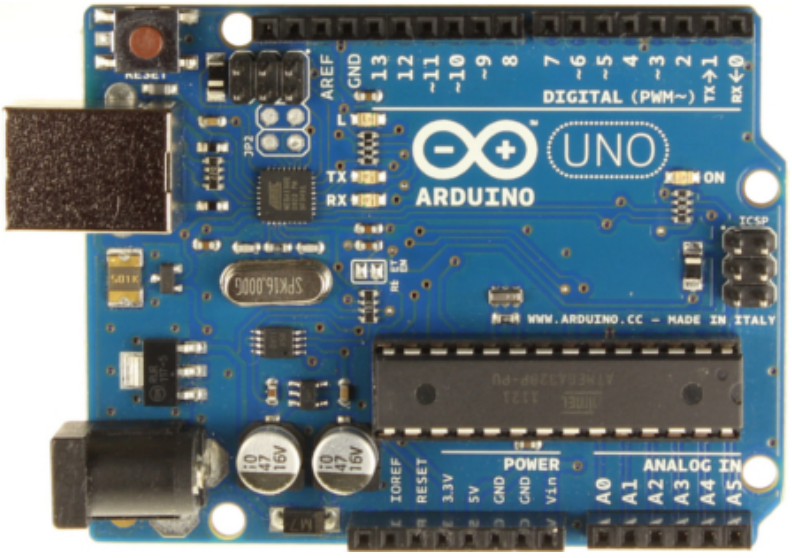

Figure 2. Arduino Uno mircrocontroller

As *DontFlushMe* progresses, community engagement is a critical step forward. Demonstrating the sensor equipment, teaching workshops on how to build a sensor, and teaching people how to understand and utilize the alerts created by the systems are critical.

II. Domains

The sewers of New York city are a place of myth and legend. Even though the system is over one hundred and fifty years old, few residents actually know how all the waste water, generated by 8.5 million residents, is handled. *DontFlushMe* aims to connect people to where their waste water goes. Doing so encourages engagement, raises awareness and empowers residents to engage in conservation efforts.

DontFlushMe encourages citizens of New York with realtime information about the status of *their* sewer system. This personalized information as well as its realtime nature enables direct action. Water conservation is, and has been a lofty goal, but by encouraging timely action participants are engaged with a clear path towards direct actions and outcomes.

The New York City sewer system as we know it began to take shape in 1849. Some of the 1850s-vintage pipes are still in use in lower Manhattan. The current system consists of over 7000 miles of pipes and 14 separate treatment facilities. “With these resources, the 1.4 billion gallons of wastewater discharged by eight million residents and workers in New York City each and every day is processed at the treatment plants”. [21]

“New York City has what is called a combined sewer system. Combined sewer systems (CSS) are sewers that are designed to collect storm water runoff, domestic sewage, and industrial wastewater in the same pipe” [22]. Approximately 70 precent of the New York City sewer system is a combined sewer system. “Sometimes, during heavy rain and snow storms, combined sewers receive higher than normal flows. Treatment plants are unable to handle flows that are more than twice design capacity

and when this occurs, a mix of excess stormwater and untreated wastewater discharges directly into the City's waterways at certain outfalls. This is called a combined sewer overflow (CSO)" [17] (Figure 3).

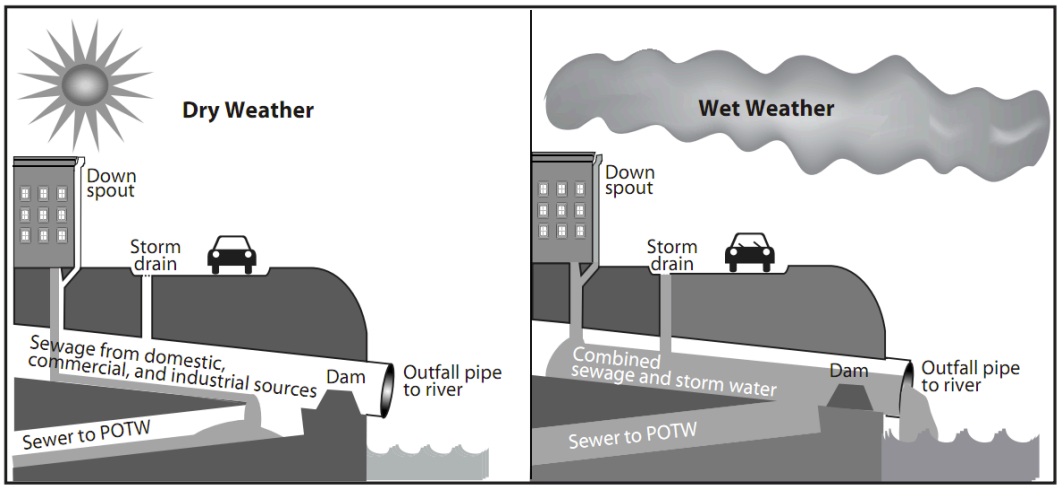

Figure 3. CSO Diagram http://www.epa.gov/npdes/pubs/

There are 460 CSOs located throughout New York City. These 460 CSOs are responsible for discharging approximately 27 billion gallons of untreated wastewater and stormwater into New York waterways each year [25]. "Just 15 of these 494 outfalls, identified as Tier 1, are responsible for spurting out over half the City's raw sewage" [6]. "Tier 1 outfalls discharge over 500 million gallons per year (mgy) [each] and comprise roughly 50% of all CSO volumes" [19]. (Figure 4)

With the number one source of water pollution coming from 460 known points in the harbor, creating change around these specific locations becomes a completely achievable task. By potentially targeting each on of these CSOs with a sensor, a broad network would connect every New York resident which allow direct targeted action.

These outfall locations are spread widely across the five boroughs. There are outfalls into every major body of water in the New York area including the Gowanus

Canal, Newtown Creek, the East River, The Hudson River, the Bronx River, and Jamaica Bay. Sewage discharge locations not only impact recreational activities but transportation as well. Three of the newly commissioned East River ferry terminals, in Brooklyn, are located directly adjacent to sewer discharge points.

Figure 4. Tier 1 CSO in New York City http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_HighRes.pdf

The vast nature of the New York sewer system creates a logistical challenge for the mitigation of CSO discharge. The perfect solution would be to create an entirely separate system to handle stormwater. The infrastructural cost related to create a secondary sewer system makes this solution completely impractical. Other solutions

that are used to mitigate CSO discharge include storage facilities and retention basins that can retain sewer overflow until it can be treated, and a variety of pretreating and screening techniques.

> “Physical structure is crucial in a system, but rarely a leverage point, because changing it is rarely simple. The leverage point is in proper design in the first place. After the structure is built, the leverage is in understanding its limitations and bottlenecks and refraining from fluctuations or expansions that strain its capacity”[13]

This project aims to introduce change into a complex system through simple tools and techniques. As described above, the sewers of New York, or any major city for that matter, are a vastly complex system. However the inputs, outputs and goals of this system are simple. Taking a systemic approach, a large scale system can be dissected into manageable sections. “Systems thinking is a way of understanding reality that emphasizes the relationships among a system's parts, rather than the parts themselves”[2]

DontFlushMe targets to reduce the volume of sanitary sewer discharge before and during these CSO events to mitigate the rate of contamination resultant from a sewer overflow. The idea of load reduction would allow the treatment plants to capture to first tenth of inch of stormwater, which contains the largest volume of contaminates, as well as prevent further contaminates from being discharged over the corse of the CSO event. By examining the inputs and outputs of this system, *DontFlushMe* aims to leverage change without the need to modify the physical infrastructure of the system.

There is one exemplary research project that tackled the complexity of managing a combined sewer system is called CSOnet. “CSONet uses data gathered from a distributed network of sensors to provide decentralized, distributed, real-time control of

the CSS's [combined sewer system] storage capacity using automated valves called smart valves." According to EmNet, the company behind the production of the project, CSOnet "will reduce CSO discharge volumes by up to 25%".[5]

Personal conservation efforts have taken hold across a variety of areas. The Toyota Prius outsold the second leading hybrid car by 7 to 1 [34] and the compact florescent light bulb reached 20% market share by 2008 [26]. These are examples of commercial success in personal conservation. These personal efforts allow participants to actively engage in conservation by making a small change. This small changes are critical to being shifting a larger system. The single act of buying a hybrid car or changing a light bulb does little to the larger system but the multiplicity of these acts cause can a significant shift.

The conservation efforts outlined as part of the *DontFlushMe* project are one approach to a incredibly complex challenge. As technology becomes increasingly accessible, low cost and ease of use, cities are finding more efficient ways to us it to tackle the problems of aging infrastructure. These technological initiatives are often classified as "Smart Cities". An example of a "Smarter Cities" application is the use "sensors embedded in mobile devices to identify vibrations that could indicate potholes or other road hazards" where this data is automatically entered into a municipal database without manual intervention [9]. Another is the use of digital parking meters that alert drivers when spaces are available and allow the drivers to make a payment using their smart phone. Both examples highlight leverage points cities are using to augment a physical infrastructure without the need for massive re-engineering.

One such leverage point for New York's CSO problem could be peak load management for commercial water customers. This would allow participating companies to be compensated for reducing sewer load at critical times. This reduction would be the result of either scaled water use or local storage. This on demand load reduction is already in place for commercial electric customers in New York. "In summer 2010, 65 facilities from 10 different City agencies participated in NYPA-managed [New York Power Authority] demand response programs, reducing demand by an average of 12 megawatts on four separate peak load days." [20]

Currently, New York has a system that allows the Department of Environmental Protection (DEP), the agency responsible for the drinking and waste water systems, to collect nearly real time water usage information from every building in the city. DEP calls this system "Automated Meter Reading" or AMR. Each building is fitted with a low power wireless transmitters that relay water meter information to a centralized system. Some of DEP's goals for the AMR are to "increase billing accuracy and provide customers with the tools they need to better manage their water usage". This AMR system would enable a positive demand reduction feedback loop to be established such as currently exists for electricity.

Other possibilities for sewer load limiting also include smart appliances that stagger or delay their wastewater production during CSO events. This system would be similar to the proposed electrical load management "Smartgrid".

Recreational users of New York's harbor are at risk of health problems from direct contact with contaminated water. As personal recreation usage of New York waterways increase, a better understanding of the health and environment impacts should also be

available. [18] The New York City Water Trail is a group of canoe and kayak launches that are operated in conjunction with the city parks department. There are 40 locations throughout the five boroughs. Each one of these locations allow for direct access to the harbor. Each one of these locations carries a posted warning sign advising about the hazards of direct contact with water from the harbor. Creating a system of alerts and notifications would allow users of these locations to determine water quality conditions in a timely manner.

The *DontFlushMe* project fits well into a the domain of citizen science. Citizen science is focused on getting people to explore problems in their own environment through a scientific process. “Citizen Science engages volunteers in the collection of ecological information.” [16]

On the technical side *DontFlushMe* relies greatly on wireless communication and environmental monitoring. The sensor modules have been designed using readily available open source hardware and software. Engaging with these open source movements allows a broad group of people to collaborate and innovate on design. Creating a device that can be replicated easily allows people to become self empowered. *DontFlushMe* engages with many aspects of the “Do-it-yourself” (DIY) movement (more technical details are available in chapter 3, Methodology).

DontFlushMe also relies heavily upon civic engagement and community activism. Community engagement is critical for the success of *DontFlushMe*. Working with pre-established organizations allows for the message of the project to be passed along through well worn communication channels. These channels allow for effective event planning and also allow feedback to be relayed from participants. This engagement also

helps to lend credibly to the project through cooperation with reputable community groups.

III. Methodology

The *DontFlushMe* system consists of remote sensors deployed into the New York sewer system as data collection points. The data is then presented in realtime using a web interface, a SMS and Twitter alert system, a phone interactive voice response system (IVR) and networked "Visualights" (Figure 5) which provide realtime ambient light visualizations of the sewer system level. The *DontFlushMe* in home visualizer allows people to quickly determine the status of the sewer system. This status update allows for more informed decisions to be made about water use.

Figure 5. "Visualight"

The tools, used to represent the data, are designed to allow access to the widest possible user base. This broad reaching access is crucial to the notion that people will adjust their water use on mass during CSO events. One less flush by every New Yorker in a single day would prevent approximately 40 million gallons of sewage from entering the harbor. "Reducing water use can decrease the total volume of domestic sewage conveyed by a sewer system, which can increase conveyance and treatment capacity during periods of wet weather and potentially reduce the volume and frequency of CSOs and SSOs."[31]

The initial pilot location for *DontFlushMe* is located in Williamsburg, Brooklyn. NCB-013, the targeted CSOs identification code, is a tier 1 CSO that discharges into Wallabout bay and is slated for the installation for the sensor prototype. NCB-013 and NCB-014 (Fig. 4) are two adjacent CSOs that are part of the Newtown creek sewer shed. The Newtown creek sewer shed serves approximately one million people and includes much of lower Manhattan including Union Square. [33] Separate data is not available for each of these CSOs but it is estimated that 666 million gallons of discharge is generated between the two.[7]

There are a wide variety of people who are looking for a way to help change their environment and reduce their impact on the environment. These people are the initial target user group. For this project to be successful this group must be expanded to encompass the general public. The simple tools created as part of this project are designed to do just that.

“Do it yourself” (DIY) users are also a target user group. Targeting the DIY community allows for people become vested in the process. The sensor and “Visualight” device are designed so that other people can build them and innovate on them. They get to make the sensor, understand how it works, share the information with their social network and become advocates for the process.

Mobile phone based alert systems are becoming widely used for a variety of purposes. Within the last month the Federal Communication Commission announced that a nation wide “Commercial Mobile Alert System” would be implemented. This system would alert people about a variety of conditions from local weather emergencies

to nation wide presidential alerts. This system is being tested in New York and Washington D.C. where it will be implemented by the end of 2011.

Ambient Devices is a company that was created as a spin off from the MIT Media Lab which specializes in the creation of devices that visualize complex information in simple ways. “The Orb is a frosted-glass ball that glows different colors to display real time stock market trends, traffic congestion, pollen forecasts, or any other Ambient information channel: weather, windspeed, pollen, traffic congestion, and more.”[4] These devices were used as inspiration for the creation of the “Visualight”.

A public pilot project is being planned in conjunction with the Newtown Creek Alliance, the Gowanus Canal Conservancy and the North Brooklyn Boat Club. This pilot will connect a group of constituents to real time information about water quality. Each one of these groups currently engages in conservation activities related to water quality. Connecting directly with end users will provide a practical opportunity to conduct user testing with a targeted audience.

The design and launch of a site for personal engagement is also planned. The site would allow people to add stories of water quality, both positive and negative, and share their personal acts of conservation. This site would also highlight community members directly engaged in water quality issues around New York.

DontFlushMe was created to raise awareness to the problem of wastewater pollution in the New York harbor. The creation of open-source accessible tools that allow people to gain a greater understanding of this situation will enable this project to succeed. The initial target group of environmentally conscious users will drive an

upswell of interest in the project. Allowing tech savvy DIYers to continue to innovate on the hardware should provide for greater reliability and increased awareness as well.

The work I've done on *DontFlushMe* has been all about and inspired by exploration. The project first began with the exploration of the Gowanus canal via canoe. This led me to explore the idea of creating a network of devices capable of monitoring the sewer system of New York. For these devices to successfully raise awareness about water quality issues, I explored the means to connect people to data in effective and unobtrusive ways. As I move forward with the project I continue to explore ways to create a personal and meaningful connection between people and the waterways of New York.

A thorough understanding of water quality problems was the first step needed to help define the project. Very quickly it became clear that sewer overflow events were the number one source of water pollution in the harbor. These overflow event are caused when a rainstorm overwhelms the capacity of treatment plants. My first instinct was to understand when and where these overflows happened and what could be done about them. I then explored the idea of creating a sensor module that would detect a sewer overflow event.

The prototype sensor module is based on the Arduino microcontroller platform. A custom circuit was designed to collect data from an infrared proximity sensor and transmit this data as a text message, SMS, via a serial connection to a cell phone. This proximity sensor, installed in a clear housing measures the water level in the CSO (combined sewer overflow) regulator. A secondary system that detects the position of the flood gate doors is planned to added redundancy. These flood gates are designed to

keep tidal flows from infiltrating the sewer system and causing a greater load on treatment plants.

The greatest technical challenge faced when developing this sensor module was power management. A stock Arduino board was inadequate for this device because of its continuos power usage. The components of a stock Arduino are designed for flexibility and therefor are less energy efficient. A custom circuit was designed that could be powered by a series of D cell batteries. By using the built in sleep functions of the Atmega 328p and its related “watchdog” timer, the circuit reduces its power load to 0.05 mA [11] during sleep cycles. These sleep cycles are limited to a maximum of 8 seconds. Maximum power savings was achieved by only triggering a sensor reading every 7 sleep cycles.

The cell phone interface is designed around the Motorola C168i. This particular phone has an integrated serial port in the headset jack. This serial port allows for simple AT commands to trigger a variety of functions on the phone. A simple Arduino library call SSerial2Mobile was employed to ensure that this communication functions properly. [29]

With a plan in place to collect data from CSO regulators, the next task was to explore how to disseminate this information. A variety of techniques seemed most suitable for this project as information accessibility is key to keeping people engaged. The first idea was to create an system that sends text messages to alert people during sewer overflow events. The second component was a ambient light visualization device that would display data from the system as colored light. Connecting both of these ideas is a website that contains information on the project as well as realtime sewer system information.

The ambient lightbulb device was designed to simplify the deployment of a visualization device to a widely diverse audience. The adage “saving electricity is as easy as changing a lightbulb” was used to market compact florescent bulbs. With this “Visualight” I coined the phrase “what if saving water was as easy as changing a light bulb”. The first prototypes of this device were designed to be stand along single purpose lights. These lights could be placed in any location of the users choosing. During the preliminary user testing, it became apparent that it would be virtually impossible to achieve a design that would be aesthetically pleasing to every audience. In reviewing the aesthetics of light fixtures, it became obvious that the simplest form for this device to take would be the actually lightbulb itself.

The compact nature of the “Visualight”, Arduino powered lightbulb, created some considerable design constraints. Providing a regulated 5v power supply to the device was achieved by using an Apple usb charger. A simple circuit board was then designed to accept the Atmega 328p chip as well as a pair of RGB LEDs and a Xbee RF module. A Digi Connectport X2 gateway is used as a means to provide internet functionality to the device. The parts used to create this device are readily available which will hopefully allow for expanded development of these devices.

The tools developed to help encourage behavioral changes in users must be designed to be user friendly, accessible, and have the lowest possible barrier to entry. This accessibility is partially achieved by utilizing a short message service (SMS) system which allows realtime alerts to be delivered across a huge range of mobile devices. With the cell phone market share among the US population reaching 96

percent [3] and 99 percent of available cell phones being capable of receiving SMS [24], this approach therefor reaches a vast portion of the US population.

The first sensor prototype for *DontFlushMe* proved that a self contained device could be constructed and made to function correctly. Further research showed that the sensor module would need to be left unattended for a greater period of time and would require a more robust range finder for detecting the water level.

The initial prototype relied on 3 D cell batteries, that in testing provided four weeks of activity without interruption. At the four week mark, the batteries still retained a sufficient charge to operate the sensor. The second prototype is designed to house 12 D cell batteries in the hope of achieving a runtime of up to 6 months. To house these batteries a larger case was selected. The new, larger case also provides a greater degree of environmental protection. Being opaque, the new case would not allow the IR range finder to be used as was in the previous design. A water resisted, externally mounted rangefinder was selected for its durability and range specifications. The original circuitry was retained including the cell phone.

The evening of September 1st, 2011, provided me with an opportunity to test the sensor module in a targeted CSO regulator. With the help of an adventurous friend, I entered the CSO regulator. I was not prepared for the volume of sewage that was flowing. During the exploration, I noticed that the department of environmental protection (DEP) had installed sensors of their own. After a close inspection, I discovered that the *DontFlushMe* sensor design was almost identical to the DEP sensor in many ways.

This test exposed one weakness in my design. The cell phone I was using to transmit data, could not receive any cellular signal. I became clear that more advanced cellular module, which supported and external antenna, would be required. This module has since been integrated into the second prototype sensor module which now supports an external antenna.

After this test, the majority of my work was be focused on garnering support for the project from the DEP and other organizations. The DEP is the organization responsible for dealing with all of New York's drinking and waste water system. For a continued pilot of *DontFlushMe* to be possible, support from the DEP is required. The bureaucratic processes associated with this engagement have become some of the most difficult parts of the project.

Garnering support from community groups is critical for the continued success of *DontFlushMe*. People associated with these groups will help maintain and install the sensors, which is critical to broaden the reach of the project. The hours required to maintain a network of 50 sensors installed in remote locations throughout New York would be prohibitive and potentially costly to a project like *DontFlushMe*. Groups already engaged with the project include the North Brooklyn boat club, situated on Newtown Creek, the Gowanus Dredgers Canoe club, on the Gowanus canal, and the New York City Water Trail Association, a city wide affinity group for boat clubs.

As part of this community building and outreach a hackathon was held in March of 2012. This event brought sponsorship from Pachube, Ushahidi and The Public Laboratory for Open Technology and Science. Community groups were invited to talk about particular problems which they face and what kinds of solutions they would like to

see developed. During the course of this event a new version of the CSO sensor was developed. This version is now slated for a large scale deployment throughout New York.

Understanding how people engage with and understand the complexity of the invisible system, which is New York City's sewer, is what *DontFlushMe* explores. From the technical creation of sensors and visualization devices and websites to the exploration of bureaucratic processes, this project broken has pushed me into new areas of exploration.

IV. Evaluation

The most difficult part about the *DontFlushMe* project has been creating a meaningfully engaging experience for participants. This engagement is the make or break for a project that relies on personal conservation and behavior change. Adding to this challenge is the fact the *DontFlushMe* targets the some what taboo subject of sewage. 31% of respondents to a survey created about *DontFlushMe* answered yes to the question; “Does the name "*DontFlushMe*" give you a bad feeling? Do you find it gross or unappealing?”. This difficulty is also compounded because the system that deals with waste water is largely out of sight from the public.

To overcome some of the stigma related to the project experiences were designed with the utmost care. Devices designed for user interaction, the “Flush Capacitor” and the “Visualight”,(chapter 3) were created to be as simple as possible. This simplicity enables the message to cut through any negative connotation perceived. Messages sent by *DontFlushMe* via Twitter used humor to relay information. Unique messages were crafted for alerts targeting each of New York’s five boroughs.

Can DontFlushMe act as a “leverage point”, “...places within a complex system (a corporation, an economy, a living body, a city, an ecosystem) where a small shift in one thing can produce big changes in everything”? [13]

The use of feedback loops ties directly to complex systems dynamics and the understanding that large systems can be broken down or changed with “leverage points”. *DontFlushMe* targets several of these leverage points with information flow and positive feedback loops. (see chapter II)

What tools can I design to engage users?

Much of the work put into dealing with this engagement has yet to be fully user tested. This user testing has been delayed because of a lack of meaningful data from the sensor system. This user testing will be a critical step in moving forward with the project. To create an experience that is as accessible as possible, techniques already currently well tested are being implemented. This includes SMS alert messages to signal when the sewer system is at or near capacity.

A text message system was chosen as a means of communication for *DontFlushMe* due to its near universal accessibly. In the United States there are now more cell phones in use than there are people. This wide spread distribution meant that access to data would not be restrictive or selective.

Can a sensor be developed that will provide meaningful and practical information?

The choice of technologies used in *DontFlushMe* has been driven by a continual desire to maintain accessibility. The sensor modules were constructed so that they could be reproduced by anyone with a some electronics experience and as part of community building workshops. The sensors were designed to be as inexpensive as possible to enable the system to be implemented broadly. The technologies used are also industry standards to withstand the harsh environments of the installation locations.

How can a website be a tool for positive engagement and encourage direct action?

Creating a website for *DontFlushMe* has been a challenge. First iterations focused too closely on the negative connotations of sewer overflows. While in some

cases people were shocked to learn about the true nature of the system, people argued that they were put off by the sheer negativity of the information. Studying websites that were designed around conservation ideas, I noted that many presented positive messages outwardly while providing in depth content to those who continued their research. The layering of content is critical to help maintain a users interest.

Current tools for understanding the effectiveness of a web campaign monitor details of a users interaction with the site. This information can tell you how many times a particular person visits the site, how much time they spend and what they look at. These metrics can only reveal the nature of the content interaction and not the level of content retention, comprehension and realistically, engagement.

One of the areas of investigation for *DontFlushMe* is centered around presenting complex data as colored light. This data visualization technique relies on the user understanding the contextual meaning around color. Cultural significances therefore affect this technique. “Almost universally, red means stop” [27]. This is of great importance to ensure that the proper meaning of the color light is understood. The success of this visualization is the most difficult part of the project to quantify. It will require extensive user testing and feedback to understand its efficacy.

The effectiveness of the *DontFlushMe* project as a concept has so far been quite high. After the initial ideation of the project a website was launched. This site has since garnered over five thousand visits with more than eleven thousand page-views. Viewers spent an average of one minute and fifty seconds on the site. A CBS news article from 2009 states that the average time spent on a website was 33 seconds. [15]

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