COST ANALYSIS FOR THE MS4 PERMITS

An Interactive Qualifying Project Report

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ABSTRACT

Stormwater runoff is the number one pollutant of water bodies in the United States. As runoff flows over impervious surfaces, it picks up pollutants and discharges directly to nearby water bodies such as lakes or rivers. The United States Environmental Protection Agency regulates stormwater runoff pollution through the Municipal Separate Storm Sewer System, or MS4, permit. Currently, Massachusetts stormwater is regulated through a 2003 MS4 permit. However, a new permit is anticipated to be issued in 2014. The goal of our project was to estimate the cost of implementing the new upcoming permit. We found the estimated cost of implementing the upcoming new permit for four case study towns with different population, area, and impervious surface area.

ACKNOWLEDGEMENTS

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We would also like to thank our advisors Corey Dehner and Stephen McCauley for guiding us through this project and providing feedback and support on our project.

We would also like to thank the four case study towns of Upton, Oxford, Webster and Westborough for their information to complete the project.

We would like to extend a thank you to the towns of Auburn and Shrewsbury for their help with our project as well.

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EXECUTIVE SUMMARY

Stormwater runoff is the leading cause of pollution in most water bodies across the United States (U.S. Enviornmental Protection Agency, 2013). Runoff is generated when precipitation from a storm flows over an impervious surface and does not permeate into the surrounding area. Urbanization has caused impervious surface coverage to increase every year. A 2012 study by the United States Department of Agriculture (USDA) Forest Service showed that tree cover in 20 different cities decreased, on average, by 0.27% per year while impervious surface coverage has increased by 0.31% per year (Nowak & Greenfield, Tree and Impervious Cover Change in US Cities, 2012). According to the Massachusetts Watershed Coalition, one acre of pavement can generate as much as one million gallons of runoff per year (Massachusetts Watershed Coalition, 2014).

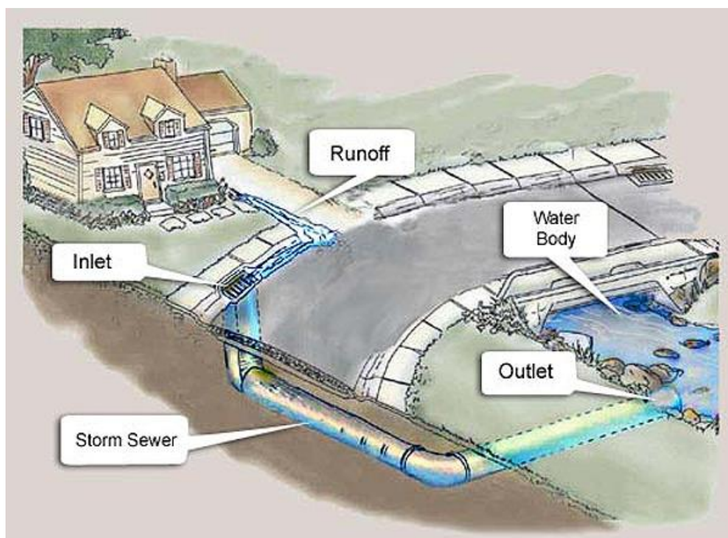

Figure 1. Simplified MS4 System

As runoff travels over impervious surfaces, it can gather up the pollutants that are on the surfaces. Common pollutants that stormwater picks up include dirt, fertilizer, gasoline, detergents, and oil. After traveling over the impervious surface, the runoff is gathered in a catch basin and then discharged by an outfall into a nearby water body. This system is called a Municipal Separate Storm Sewer System, or MS4. A simplified version of this system can be seen in Figure 1. As seen in the figure, runoff does not go to a treatment facility before it is discharged; this means that all pollutants the runoff picks up as it travels to the catch basin are carried to nearby water bodies.

Prior to the 1970s, stormwater was not regulated at all. It was not until 1987 that the United States Congress mandated that the United States Environmental Protection Agency (USEPA) require that MS4s obtain a National Pollution Discharge Elimination System (NPDES) permit. The first wave of permits went out in 1990 and required cities with populations over 100,000 to comply with the MS4 permit. In 1999 the second wave of permits went out to all urbanized areas. These MS4 permits required cities and towns to comply with six minimum control measures in order to reduce stormwater runoff pollution. These six control measures are:

1. Public education and outreach
2. Public involvement and participation
3. Illicit discharge detection elimination
4. Construction site stormwater runoff control
5. Post construction stormwater management in new development and redevelopment
6. Pollution prevention and good housekeeping in municipal operations

Each measure specifies what towns must do in order to comply with the permit. For example, for the illicit discharge detection and elimination control measure, towns must have their stormwater infrastructure mapped using a global positioning system (GPS).

While each measure has its own specifications, they also have their own costs. Stormwater runoff is the largest contributor to water pollution in the country, but proper stormwater management can be very costly to towns.

According to Frederick Civian, the stormwater coordinator for the Massachusetts Department of Environmental Protection, municipalities anticipate the USEPA issuing a new Massachusetts MS4 permit within the next year. This permit is expected to have much more detailed tasks for municipalities to complete. For example, municipalities must complete water sampling for all outfalls. This task is new and is expected to be difficult to complete due to the scope of the task. The task states that municipalities have five years to test all of their outfalls for pollutants such as chlorine, ammonium, and surfactants. Some tests such as a bacterial test must be sent to a lab. The difficulty comes in when towns do not have a person that has the expertise to take the outfall samples.

One way towns can cut costs is if they pool their resources together. This can be accomplished by joining together in a group or coalition. For our project we worked with the Central Massachusetts Regional Stormwater Coalition (CMRSWC) and analyzed what costs could be shared among CMRSWC members.

In order to comply with this new upcoming permit, towns will have to increase their spending towards stormwater related tasks. In the next section we will discuss our project's overall goal and the objectives we set to complete our goal.

METHODOLOGY

The goal of our project was to evaluate the total cost of implementing the upcoming MS4 permit requirements for four central Massachusetts municipalities. In order to successfully complete our goal, we worked to accomplish the following five objectives:

1. Identify the costs that Upton, Oxford, Westborough, and Webster (the case study towns) currently spend in their respective stormwater programs to comply with the 2003 MS4 permit.

2. Identify the new costs towns will need to implement to comply with the upcoming Massachusetts permit.

3. Evaluate the costs we have identified by control measure

4. Identify benefits the CMRSWC offers to towns

5. Compare the costs between implementing the permit individually versus implementing the permit with the help of the CMRSWC

Through our background research and several interviews with key stakeholders we determined how to create our cost analysis for each of the towns. We conducted interviews with town engineers, consultant companies, directors of the department of public works, and relevant personal from each of the case study towns to identify costs that are relevant to the MS4 permit. When conducting these interviews, we asked specific cost questions about each stormwater related task the town completes. These interview questions were built around each of the towns documented stormwater reports. Sample interview questions can be found in Appendix A.

During the course of our project we were able to go out and conduct field work in each of the case study towns. For the towns of Upton and Westborough, we did three days of mapping stormwater structures such as outfalls, manholes and catch basins. We mapped these structures using an Asus tablet and a Leica global positioning system (GPS) unit. For Oxford and Webster we spent three days conducting dry weather inspections, water sampling, and marking outfalls. For water sampling, we used the Central Massachusetts Regional Stormwater Coalition's sampling kits. These tasked helped us understand what each municipality must complete for the upcoming permit.

FINDINGS

During our seven weeks working on this project, we assessed the cost of implementing the expected MS4 permit for four towns by conducting a case study for each of the four towns. In each case study, we learned what Upton, Webster, Westborough and Oxford have done to comply with the MS4 permit currently in place by researching their stormwater annual report and interviewing the town engineers, director of department of public works, contractors or relevant personnel. As stated above, we went to each town to conduct field work. This gave us an idea of labor cost for each task

We developed several key findings after we finished our case studies as well as analyzing and compiling the data we have collected.

The overall yearly cost for each town to implement the MS4 permit in place now.

From the case studies, we discovered the total cost Upton, Oxford, Webster and Westborough was spending for each of their stormwater programs. We divided the cost by one-time costs and yearly costs. For example, mapping stormwater structures and bylaw creation were included as one-time costs while street sweeping and catch basin cleaning were included in yearly costs. According to the permit, all programs must be completed in five years so we divided the one-time costs by five to get a yearly equivalent cost. For the town of Upton, the total yearly cost is $52,950. For town of Oxford, the yearly cost is $143,664. For town of Westborough, the yearly cost would be $307,500 which $220,000 of that is to be paid for the general staff (number given to us which signifies the labor cost for all stormwater related tasks and personnel). For town of Webster, the total yearly cost is $235,780.

The cost for all municipalities to comply with the new permit.

We also divided costs between baseline costs and varying costs. Baseline costs were costs that did not range widely between towns. For each of the factors we identified as baseline costs, we also created a range that we expect each town will fall under. The table below showcases the costs we have identified as a baseline cost. A table below outlines some of the costs we've identified as baseline costs as well as their price range.

Table 1. Sample baseline cost

Task	Low Estimate [$]	High Estimate [$]
Public Education and Outreach	6,000	10,000
Public Involvement and Participation	10,000	15,000
Create an ordinance or	6,000	10,000

bylaw for sediment control for construction sites		
Have a staff member inspect BMPs present within construction sites	7,000	10,000
Have a staff member to continue inspecting BMPs after construction is finished	7,000	10,000
Create an ordinance or bylaw for detecting and eliminating illicit discharges	6,000	10,000

Varying costs include replacing pipes and catch basins, best management practices (BMP) maintenance, and mapping. Each of these tasks varied widely between the four towns we studied. We found that as the towns' population increased, their cost for both what they are doing now and what we estimate they will have to do, went up. Below is a chart of the population versus expected cost for the new permit.

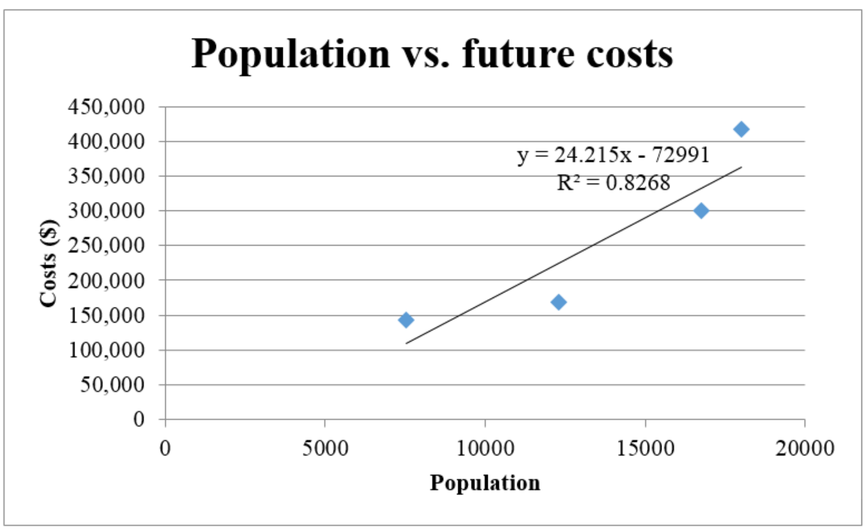

Figure 2. Population vs. future cost

The table below shows some of the varying costs for two control measures separated by towns.

Table 2. Sample varying costs

Control Measure	Costs [$]			
	Upton	Oxford	Webster	Westborough
Illicit Discharge, Detection, and Elimination Program	17,500	56,000	309,000	100,000
Good Housekeeping and Pollution Prevention	23,000	197,500	213,000	55,000

The cost that can be shared among municipalities in Central Massachusetts Regional Stormwater Coalition (CMRSWC).

Some of the costs that members of the coalition share are the Leica units, maintenance on tools, one-on-one support, People GIS training, sustainable financing and access to the CMRSWC website. The table below details programs that the CMRSWC offers.

Table 3. Sample shared costs

Program	Costs [$]		
	Coalition	Average cost for towns in the coalition	Average cost for towns ***not*** in coalition
Tata & Howard invoices	159,500	5,317	5,317
People GIS	52,875	1,762	**1,762**
Central Massachusetts Regional Planning Commission	1,857	62	0
Virtual Town Hall Website Development and Hosting	9,481	316	9,481
Graphic Designer	500	17	0

Public Education and Outreach Tools	2,612	87	2,612
Tablet Devices (13)	7,975	613	613
Water Quality Meters and Kits	13,945	465	465
Mapping/GIS Tools (includes two Leica's)	55,113	1,837	18,516
Total	***302,358***	***10,476***	***36,766***

People GIS agreement is assumed to be written for 30 municipalities, so we assumed that this amount would divide by 30 to find price per town. This could not be the case so we took the dividend as the lowest amount possible

The "Coalition" column illustrates the total expenditures the CMRSWC has spent for each of the programs listed. In order to find an equivalent cost that each municipality receives from membership we took the total expense and divided it by 30. This gave us a number that each of the 30 municipalities receive which can be seen in the "Average Cost in Coalition" column. Finally, we looked at what the cost would be if a municipality would individually implement each of the tasks listed which can be seen in the last column, "Cost for singular town". As can be seen in the table, if a town were to implement the programs offered by the CMRSWC it would cost roughly $37,000.

Cost that this project did not include.

For this project, we focused our efforts on the cost of compliance with the six control measures in MS4 permit. However, due to the time limitation of our project, we excluded some potential costs of compliance with the MS4 permit. Sanitary Sewer Overflow (SSO) and Total Maximum Daily Load (TMDL) are two important requirements in the MS4 permit. However, the towns we worked with did not report any SSO's and Webster was the only town with a TMDL, so we did not account for the cost of these two programs in our findings.

RECOMMENDATIONS

After completing our study we have many recommendations for the MassDEP, Central Massachusetts municipalities, and future project groups. We offer these recommendations with the hope that municipalities can prepare for the upcoming MS4 permit and can expand their stormwater management programs. Additional research should be done on additional cost drivers of the MS4 permit and future permits.

The Coalition should Share Additional Resources with Member Municipalities

One recommendation we have for municipalities is to increase the amount of resources member municipalities share. Right now major resources the CMRSWC offers include water sampling kits and the Leica units.

The Coalition Should Provide Additional Training Opportunities to Member Municipalities

Another recommendation for the municipalities is to attend the training for sampling and mapping. In some towns, there are only one or two employees that can complete these tasks but in others they do not have a single employee. If municipal employees are trained on these tasks, it will be less costly compared to hiring a consultant to come in and complete the task for them

Future Research Should be Done on the cost of TMDLs and SSOs

For future projects, we recommend the project groups use our data and information collected to further research costs of the MS4 permit. One specific factor is the cost of TMDL's which was not included in our report. These TMDL's can range widely and only apply to specific municipalities.

Future Research Should be Done on Additional Funding Opportunities Available to the Coalition

Another future project we recommend would be identifying funding mechanisms for implementing a stormwater utility. A municipality like Shrewsbury has passed a stormwater utility but has not found a way to charge residents fairly. Some ideas for charging a stormwater utility include charging through impervious surface area, total area, a flat residential rate or others.

CONCLUSION

It is our hope that after reading our report, towns will have a better understanding of the upcoming Massachusetts permit and its associated costs. The costs and methods presented should help towns realize and perhaps, prepare for the financial implications of the new anticipated MS4 permit. The task will be difficult but with correct awareness and actions, towns will be able to be in compliance and more importantly, work to preserve our environment.

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LIST OF ACRONYMS

BMP	Best Management Practice
CIC	Community Innovation Challenge
CMRSWC	Central Massachusetts Regional Stormwater Coalition
CWA	Clean Water Act
DPW	Department of Public Works
FWPCA	Federal Water Pollution Control Act
GPS	Global Position System
IDDE	Illicit Discharge Detection and Elimination
IQP	Interactive Qualifying Project
LID	Low Impact Development
MA	Massachusetts
MassDEP	Massachusetts Department of Environmental Protection
MS4	Massachusetts Separate Stormwater Sewer System
NH	New Hampshire
NPDES	National Pollution Discharge Elimination System
NRDC	Natural Resources Defense Council
SSO	Sanitary Sewer Overflow
SWMP	Stormwater Management Plan
TMDL	Total Maximum Daily Load
USEPA	United States Department of Environmental Protection
WPI	Worcester Polytechnic Institute

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1.0 INTRODUCTION

Every year people fertilize their lawns, and every year a high amount of phosphorus, a common chemical found in fertilizer, is found in water bodies in the United States. When it rains after fertilizer is put down or when people use too much fertilizer, stormwater runoff has the potential to pick it up and deliver it to nearby storm drains. These storm drains are part of a large system called Municipal Separate Storm Sewer System or MS4's for short. When pollutants travel over imperious surfaces like asphalt they are carried by stormwater. Stormwater is generated when rain or snowmelt flows over land or impervious surfaces and does not permeate into the ground. As the runoff flows over impervious surfaces (paved streets, parking lots, and building rooftops), it accumulates pollutants that could adversely affect water quality if the polluted runoff is discharged (U.S. Environmental Protection Agency, 2012). The stormwater that travels through MS4s usually do not travel to facilities that treat the contents; the stormwater, pollutants and all, just flow into the waters of the surrounding area. Some pollutants are removed from the stormwater through natural processes, such as traveling through wetlands, but often the amount of pollutants is overwhelming. This means that we are sending pollutants from the streets directly into our rivers, lakes and streams.

The Charles River, for example, had long suffered from excessive amounts of phosphorus which came from polluted stormwater runoff. The phosphorous acted as a fertilizer for the river and fed the blue-green algae which caused a dramatic growth of the algae. When blue-green algae die, they release toxic materials which can be very harmful to humans and animals. Meanwhile, when these algae decompose, it depletes the amount of dissolved oxygen that aquatic life needs to survive (Rothe, 2012).

In Massachusetts, both the United States Environmental Protection Agency (USEPA) and the Massachusetts Department of Environmental Protection (MassDEP) work to address the stormwater runoff issue. The USEPA regulates stormwater pollution through a federal permitting agency called the National Pollution Discharge Elimination System (NPDES) permits. The MS4 permits are part of the NPDES permits and contain six control measures which municipalities must comply with. These control measures dictate different aspects of stormwater management including increasing awareness of stormwater issues and methods to address stormwater pollution. Massachusetts was issued its MS4 permit in 2003 and expects a new permit to be issued sometime in 2014. In 2013, New Hampshire was issued a new draft MS4 permit which is expected to mirror the upcoming Massachusetts permit.

The implementation of the MS4 permits requires the expenditure of financial, labor and technical resources from municipalities. Many of the municipalities cannot afford the implementation costs and may lack the technical expertise and necessary equipment to fully comply with the new permit requirements.

For our project, we worked with the Central Branch of the Massachusetts Department of Environmental Protection and conducted a cost analysis of the implementation of the expected new MS4 permit for the towns of Upton, Oxford, Westborough, and Webster. We broke down the tasks associated with the six control measures of the MS4 permit and analyzed the cost of implementing each one. In order to determine the costs associated with implementing the MS4 permit, we researched documents such as stormwater annual reports from municipalities; conducted interviews with important stakeholders which included consulting companies, town engineers, and the director of the Department of Public Works in each town; and completed field work to get a full understanding of all costs associated with MS4 permit compliance. We also analyzed the benefits sharing resources between towns through forming coalitions.

It is our hope that Massachusetts municipalities will be able to use our cost analysis to make educated decisions about how best to approach stormwater management and MS4 compliance within their town.

In chapter two of this report we introduce the background to this project, including discussion of stormwater pollution and the evolution of stormwater management. In chapter three, we explain our methodological approach to achieving the project goal. In chapter four we describe our findings and recommendations for the towns. Lastly, we offer our project conclusions in chapter six.

2.0 BACKGROUND

2.1 STORMWATER/STORMWATER RUNOFF

According to the United States Environmental Protection Agency (USEPA), "Stormwater runoff is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and does not percolate into the ground." (U.S. Environment Protection Agency, 2012). Urbanization has turned land previously dominated by grass or fields, to be covered by impervious surfaces. In 2012 the United States Department of Agriculture (USDA) Forest Service analyzed 20 different cities and found that, on average, tree cover in these cities has decreased by 0.27 percent/year while impervious surface coverage has increased by 0.31 percent/year (Nowak & Greenfield, Tree and Impervious Cover Change in US Cities, 2012).

Without appropriate management of stormwater, urbanization can have disastrous impacts on our environment. Unlike the water that leaves your house through pipes, stormwater does not get treated before it is discharged into a body of water which can cause heavy pollution in surface waters (Hites & Biemann, 1972).

Runoff is not only limited to stormwater, it can also be caused by melting snow. In areas that use salt to keep the roads from becoming icy, the runoff from the snowmelt can carry the salt to nearby vegetation (New Hampshire Department of Environmental services). Some other pollutants snowmelt can carry include coal or gas combustion products from exhaust systems (Zhu, Xu, Yan, & Guan, 2012). These pollutants come from the atmosphere due to the snow's ability to absorb the pollutants from the air as it falls (Zhu, Xu, Yan, & Guan, 2012). Snowmelt is becoming a bigger issue due to global warming. In 2007 the Intergovernmental Panel on Climate Chance stated that extreme weather events such as heavy rain and snowfall have become more common around the globe (Intergovernmental Panel on Climate Change, 2007). Cities are going to have to learn to incorporate systems to deal with excessive rain and snowfall and the resultant urban runoff. The lack of preventative strategies and comprehensive stormwater management plans has had serious environmental consequences.

2.1.1 WHY SHOULD WE CARE?

2.1.1.1 Pollutants

How does stormwater runoff travel to water bodies? Municipal separate storm sewer systems, orMS4s, transport stormwater runoff into nearby waterways through a system of pipes (NATIONAL RESEARCH COUNCIL, 2008). These waterways consist of rivers, streams, and bays. Because stormwater is not processed by a water treatment center before being discharged into surface water bodies, it can cause pollution in urban areas (United States Envirnmental Protection Agency, 2012). As illustrated in Figure 3 Simple MS4 System, runoff travels through the storm sewer and directly into the water body the MS4 discharges into.

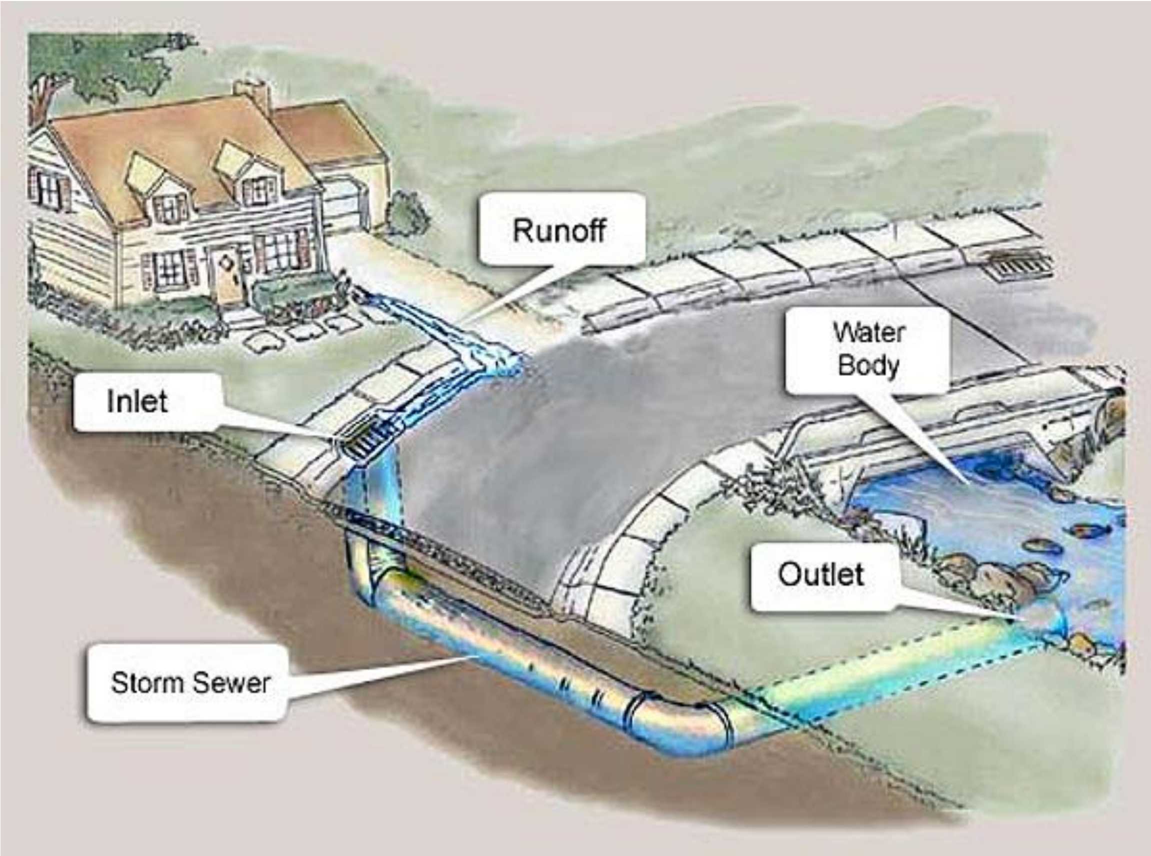

Figure 3 Simple MS4 System

Retrieved from: https://www.deldot.gov/stormwater/images2/drain_full.jpg

Pollutants are picked up when stormwater runs over impervious surfaces such as pavement or buildings, as these surfaces do not allow water to permeate in a natural filtration process. This is not a small problem. One acre of pavement can generate one million gallons of runoff per year (Massachusetts Watershed Coalition, 2014). According to an impervious coverage study done by the USDA Forest Service in 2012, 61.1% of New York City is covered by impervious surfaces such as buildings and roads (Nowak & Greenfield, Tree and Impervious Cover Change in US Cities, 2012). Some of the common pollutants stormwater can pick up are dirt, fertilizers, pesticides, oil, and grease. Stormwater that has a high concentration of phosphorus, the main chemical in fertilizer, causes the most harm to lakes and rivers (Waschbusch, Selbig, & Bannerman, 1999). Phosphorus causes algae to bloom in the water, which lowers the oxygen level in lakes and rivers (ld.). Aquatic life needs oxygen to breath. Consequently, very few aquatic species can survive in oxygen depleted water (ld.).

The Charles River is often used as an example of why stormwater management is so important. The river is the largest river in the greater Boston area and has about 100 MS4s discharging into it (Hites & Biemann, 1972). During a flow test in the 1970s, the river was kept to a low flow rate as it was controlled by two dams and the only inputs the river received were from stormwater runoff and occasional untreated sewage (Hites & Biemann, 1972). This allowed scientists to conclude that the excessive pollution in the Charles River was due to urban stormwater runoff. As a result of this finding, the USEPA and Massachusetts Department of Environmental Protection (MassDEP) took action to keep the phosphorus levels in the river to a minimum (Hurley & Forman, 2011). In 2007, Federal and State regulators approved a Total Maximum Daily Load (TMDL) for the Charles River. According to the USEPA, "[a] Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards" (United States Environmental Protection Agency, 2013). The TMDL report for the Charles River stated that to restore the river, the phosphorus load had to be reduced by 65% from industrial, commercial, institutional, and residential sources (Hurley & Forman, 2011).

2.1.1.2 Impacts of Stormwater Management

The pollutants that stormwater runoff secures flow into area surface water bodies which can harm our environment. Pollutants stormwater picks up from runoff are the leading cause of pollution in rivers, lakes, ponds, and streams (U.S. Environmental Protection Agency, 2012). As illustrated by the Charles River, algal blooms appear in water bodies that have too much phosphorus and leads to depleted oxygen levels. The aquatic life in these water bodies suffers from lack of oxygen and dies off as a result, yielding a river, stream or lake with very low biodiversity. Low biodiversity is an indicator for an unhealthy water body.

However, poor water quality need not be the end of the story. The Charles River has made a huge recovery as a result of appropriate stormwater management (U.S. Environmental Protection Agency, 2012). However, mismanaged stormwater can alter stream flows and increase flooding (Oregon Environmental Council, 2007). This in turn can endanger private and public infrastructures or destroy wildlife habitats (Id.).

Conversely, appropriate management of stormwater can reduce these impacts. Stormwater management has slowly been adopted and incorporated into environmental planning since the 1972 amendments to the Clean Water Act.

2.2 HISTORY OF STORMWATER MANAGEMENT

2.2.1 EARLY STORMWATER MANAGEMENT

Both federal and state governments play a role in stormwater management. However, stormwater management has traditionally been a local government responsibility. Until recently, the goal of local government in managing stormwater was to control the quantity of stormwater runoff and simply make it move as fast as possible away from places where it could cause damage (Tyer, Stormwater Management: Moving to the Top of the Agenda, 1993). In 1976, the International City Management Association, a nonprofit organization that offers a wide range of services to local government communities, stated that while it was obvious that stormwater contained pollutants, the effect of polluted stormwater to the receiving body water was not that obvious. As a result, local governments struggled to decide how to handle stormwater runoff (Id.).

The USEPA recognized the need for more information and subsequently, between 1978 and 1983 in a program called the Nationwide Urban Runoff Program, collected data on stormwater runoff in 28 cities nationwide (Id.). As a result of this study, stormwater runoff was concluded to be a serious source of water pollution (Id.).

2.2.2 THE CLEAN WATER ACT

"The story of modern federal legislation begins with the Federal Water Pollution Control (FWPCA) Act of 1948" (Murchison, 2005). As the first federal law that attempted to comprehensively address water pollution, the 1948 act charged the federal government with assisting states in water quality matters (Murchison, 2005). The federal government's role has evolved significantly since 1948 from supporting research and finances to administering a federal discharge permitting program.

The 1972 amendments to the FWPCA helped created the present day framework of the Clean Water Act (CWA). The Clean Water Act established a basic structure for regulating the discharge of pollutants from point sources into navigable waters of the United States (33 U.S.C. 1251 et seq.). The 1972 amendments to the CWA required municipalities to acquire National Pollutant Discharge Elimination System (NPDES) permits to discharge pollutants from a point source into a navigable waterway (U.S. Environmental Protection Agency, 2013). The USEPA defines a point source as "any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill, leachate collection system, vessel or other floating craft from which pollutants are or may be discharged" (U.S. Environmental Protection Agency, 2011). Nonpoint source refers to runoff that comes from rainfall or snowmelt and travels over a surface before entering an MS4 system. The NPDES permits are authorized by the federal CWA in order to control water pollution by regulating discharges from point sources.

The federal Clean Water Act is administered by the USEPA. The state of Massachusetts has its own Clean Water Act, which is administered by the Massachusetts Department of Environmental Protection (MassDEP). The Massachusetts CWA essentially mirrors the federal CWA and gives the MassDEP the power to administer programs to regulate and restore the water quality of publicly owned lakes and ponds within the state (Massachusetts Department of Conservation and Recreation). It also allows the MassDEP to establish areas of special interest in order to issue regulations to protect against hazards such as oil spills (Massachusetts Department of Conservation and Recreation).

Despite the improved quality of the nation's surface waters since the 1972 regulation of point source pollution, nonpoint source pollution continued to be a major contributor of pollution into waterways from nonpoint sources. The primary nonpoint source polluter is stormwater runoff (Andreen & Jones, 2008). From the amendments to the CWA up until the 1990's there was a dispute over how to manage stormwater.

2.2.3 BIRTH OF THE MS4 PERMIT

Although stormwater runoff starts as a nonpoint source, when it is collected by a catch basin it becomes part of the MS4 system and is considered a point sources as it is discharged from an outfall into a water body. In 1973 the USEPA tried to create regulations exempting MS4s from the NPDES permitting system if the MS4 did not contain industrial or commercial contamination (Harrop S. D., 2011). The USEPA felt that it was an impossible task for them to regulate each and every MS4 in the country.

In 1977, the Natural Resources Defense Council (NRDC) sued the USEPA, claiming that the USEPA could not exempt MS4s from the permitting program, under section (§) 402 of the CWA. (Natural Resources Defense Council v. Costle, 1977). The D.C. Circuit Court agreed with the NRDC, though the USEPA did not easily comply with the ruling.

Congress was eventually forced to make the USEPA regulate MS4 discharges due to concern over the adverse effects of stormwater runoff. In 1987 Congress added § 402(p) to the CWA which set up a basic program for stormwater discharges. The new addition established priorities, deadlines, and application requirements while also providing relief to nonindustrial and municipal entities from NPDES permit requirements (Harrop S. D., 2011). Congress expressed that the USEPA "shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system design and engineering methods, and such other provisions as the Administrator of the State determines appropriate for the control of such pollutants" (United States Congress, 2011). "Maximum extent practicable" was a new term for stormwater management that allowed the USEPA to create a flexible MS4 permit program without set limits for each permittee.

This new permitting approach for the NPDES program required municipalities to develop their own stormwater management programs (SWMP) and best management practices (BMPs) to reduce pollution instead of having definite requirements.

2.3 2003 MS4 PERMIT

2.3.1 CONTROL MEASURES AND DESCRIPTIONS

In 2003 the USEPA issued its first set of MS4 permit requirements. After implementing Phase II of the municipal separate storm sewer system permits in 1999, so that all sizes of MS4s were covered by the regulation, the USEPA designated six minimum control measures that municipalities must meet in order to comply with the permit. They are (U.S. Environmental Potection Agency, 2008):

1. Public education and outreach
2. Public involvement and participation
3. Illicit discharge detection elimination
4. Construction site stormwater runoff control
5. Post construction stormwater management in new development and redevelopment
6. Pollution prevention and good housekeeping in municipal operations

Each control measure must be implemented in the towns' stormwater management program (SWMP) using best management practices (BMPs) that the permittee finds appropriate for their community. This allows leeway for towns with limited resources.

The first control measure states that a municipality must educate the public about stormwater and stormwater related issues through various means. **Public education** could be anything from holding a public workshop to creating "no dumping" signs near catch basins.

The next control measure states that municipalities must have **Public Involvement and Participation** in their SWMP. Examples of public involvement and participation include volunteer organizations, such as the Boy Scouts of America, giving out pet waste bags, or monitoring a stream. This control measure, along with Public Education and Good Housekeeping (discussed below) tend to be easier for municipalities to implement.

The **Illicit Discharge Detection Elimination** (IDDE) control measure is arguably the most important and complex of the six. The major goal of this control measure is to detect and prevent illicit discharges into the MS4s. According to the 2003 Massachusetts MS4 permit, "[a]n illicit discharge is any discharge to a municipal separate storm sewer that is not composed entirely of stormwater" (U.S. Environmental Potection Agency, 2008), with the only exceptions being discharges that are allowed by another NPDES permit or discharge due to firefighting activities. The municipalities must also, at a minimum, map its stormwater outfalls and state the names of the receiving water bodies. While not required, the 2003 Massachusetts MS4 permit recommends mapping the entire stormwater infrastructure consisting of stormwater outfalls, catch basins, manholes, and pipes, but only requires outfalls to be mapped.

In order to monitor illicit discharges, the permittee must prohibit, through an ordinance or regulatory mechanism, illicit discharges into an MS4. The ordinance or bylaw must state that the IDDE system has to be able to identify non-stormwater discharges, such as illegal dumping, and have a procedure for documenting and evaluating the impacts of the illicit discharges. Using the information from documenting and evaluating illicit discharges, the municipality must inform the public about the dangers of illegal discharge and dumping.

The **Construction site stormwater runoff control** and **Post construction stormwater management in new development and redevelopment** control measures are designed to prevent sediments or chemicals found on construction sites from entering the MS4s. The 2003 Massachusetts MS4 permit states that the municipality must implement a program to reduce any polluted runoff caused by construction if the volume of the disturbance is greater than or equal to one acre of land. The programs created by these two control measures, at a minimum, must include an ordinance to regulate sediment and erosion; enforce sanctions (monetary and non-monetary) for companies that are not complying; and must control wastes such as chemicals, litter, or sanitary wastes from discharging into an MS4.

During construction periods, the company responsible for building must present a site plan to the municipality. After the construction is done, the site must also address stormwater issues that may impact water quality and follow a program set forth by the permittee to make sure all controls that were put into place during construction continues to prevent or minimize the impacts of stormwater on surface water quality.

The currently active Massachusetts MS4 permit was issued in 2003 and has not been revised since. The MassDEP anticipates that the new Massachusetts permit will have more detailed requirements for each of the six control measures and will be similar to the 2013 New Hampshire draft MS4 permit (U.S. Environment Protection Agency, 2013).

2.3.2 BEST MANAGEMENT PRACTICES

In order to comply with each of the six minimum control measures a municipality must use best management practices, or BMPs, which the municipality has decided as the best course of action that they can take. This gives municipalities freedom to develop their SWMP as they see fit. The USEPA lists common BMPs on their website for municipalities to view (U.S. Environmental Protection Agency, 2012). Other resources are available for states such as their respective state environmental agency and non-government organizations. In Massachusetts, the MassDEP, the CMRSWC, and the Massachusetts Watershed Coalition serve as valuable resources for municipalities.

BMPs can be classified as either non-structured or structured. Non-structured BMPs are usually educational or pollution prevention practices designed to limit the effects of pollution in stormwater runoff (Harrop S. D., 2011). These non-structured BMPs include educating the public on the adverse effects of improper chemical disposal, such as pesticide or fertilizer (Harrop S. D., 2011). Non-structured BMPs are generally less costly but are not monitored in a way to show improvements in water quality (Natural Resources Defense Council, 2014). Structured BMPs utilize methods such as wet basins and constructed wetlands to reduce pollutants. Unlike a non-structured BMP, the structured BMPs show improvements in water quality through past records and tests. Structured BMPs are more costly, but can effectively remove large quantities of pollution (Natural Resources Defense Council, 2014). The six control measures all fall into one of the two categories of BMPs.

BMPs allow for a wide variety of different plans to be created. Some plans are more effective than others due to municipalities having more resources than others, but all SWMPs are designed to reduce the effects of stormwater on our environment.

2.4 MOVING FORWARD WITH THE MS4 PERMIT

2.4.1 NEW HAMPSHIRE 2013 DRAFT PERMIT

The USEPA is in the process of creating a new MS4 permit for the state of Massachusetts (U.S. Environmental Protection Agency, 2013). The new Massachusetts permit is expected to mirror New Hampshire's draft permit they were issued in 2013. New regulations for the 2013 New Hampshire draft permit can be seen in the table below.

Table 4. New regulations in the 2013 New Hampshire MS4 Permit

Control Measures	New regulations
Public education and Outreach	• Two different messages sent to the four different groups (residential, commercial, construction, and industrial) within a minimum of one

	year apart
Public involvement and Participation	• Give more opportunities for public participation • Post the Stormwater Management Plan online
Illicit Discharge Detection and Elimination	• Map outfalls, receiving waters, open channel conveyances, catch basins, manholes and connections to other MS4's and many more • Municipalities must now complete dry and wet weather screening of outfalls • Municipalities must conduct dry and wet weather inspections of catch basins and outfalls
Construction Site Stormwater Runoff Control	• Control sediment and soil on the construction site and attempt to eliminate erosion that could travel into the MS4's • Construction companies must now control the disposal of building materials, concrete truck washouts, litter and many others
Stormwater Management in New Development and Redevelopment	• Attempt to maintain pre development site hydrology which is the water cycle of the area (construction should not massively change the water cycle of the area) • Municipalities now must look into street and parking lot designs within two years of the effective date of the permit. They must determine if changes can be made to these to make sure stormwater is kept as kept as close to its source as possible
Good Housekeeping and Pollution Prevention	• Have a specific procedure for street sweeping and more frequent street sweeping and cleanings • Municipalities must report annually how many miles cleaned and the amount of material removed from the streets • Establish procedures and known planned times for stormwater treatment

	system inspections with an absolute minimum of annual inspections of the systems

(U.S. Environmental Protection Agency, 2013)

2.4.2 CENTRAL MASSACHUSETTS REGIONAL STORMWATER COALITION

Initially formed by a group of 13 municipalities in 2012, the Central Massachusetts Regional Stormwater Coalition (CMRSWC or coalition) was established with the goal of collectively addressing municipal stormwater management (CMRSWC, 2012). These towns are required to implement the 2003 Massachusetts MS4 permit. However, for many towns the numerous MS4 permit requirements are difficult to comply with (Mass Gov, 2012). Towns may lack resources such as man-power, funds, and expertise (ld.). The CMRSWC was formed in order to cut the costs for municipalities. The CMRSWC shares stormwater information, surface water resources, and the need to ensure the long-term protection of these resources on a platform provided by CMRSWC (CMRSWC, 2012). Working as a group allows the CMRSWC member municipalities to efficiently meet the requirements of the MS4 permit (Mass Gov, 2013).

Since its inception, the CMRSWC has been able to function largely due to its receipt of Community Innovation Challenge (CIC) Grant funding. The CIC Grant Program was developed by the Patrick Administration in 2012. “The program encourages and incentivizes regionalization based upon the belief that the most crucial and visible interactions between government and citizens occur locally." (Mass Gov, 2012). The CMRSWC is one of the beneficiaries of this program. According to the CIC 2012 annual report, this program provided the CMRSWC $310,000 in funding for helping the municipalities to implement the MS4 permit. The Coalition has received funding from the CIC grant from 2012-2014, but does not expect to receive funds in the future.

The CMRSWC offers benefits for its members such as information about different BMPs that towns may implement to comply with the permit, use of a Leica GPS unit for stormwater mapping, and the CMRSWC provides field testing kits for stormwater sampling. Municipalities that are part of the Coalition are able to access this information for themselves and use the information to help them comply with the MS4 permit. As a result of the CMRSWCs initial success, 17 additional municipalities have joined the CMRSWC since its inception (CMRSWC, 2012).

2.5 ANALYZING COSTS FOR MUNICIPAL STORMWATER MANAGEMENT: LEARNING FROM CASE STUDIES

2.5.1 INTRODUCTION

A cost analysis is a process that estimates the strengths and weakness of activities or functional requirements for a business. This process is used to determine options for adopting practices in terms cost savings (Rodreck, Ngulube, & Dube, 2013). In the simplest terms, a cost analysis is a financial breakdown in which the benefits of implementing the project are subtracted from the costs of implementation and maintenance (Reh). For any project, the benefits can be either monetary or worldly.

Monetary benefits include saving money on projects, while worldly benefits include environmental impacts such as better air or water quality.

2.5.2 CASE STUDIES

We have studied some case study examples related to stormwater management. The three categories are: case studies directly on each minimum control measure, case studies on cost analysis approach that is related to storm water management cost, and case studies on cost-effectiveness.

For the case studies on each minimum control measure, we identified the best management practices (BMPs) that are used, and identified costs that are considered by the corresponding research group. For the case studies on cost analysis approach, we studied the methods that other researchers used when conducting cost analysis related to stormwater. For the case studies on cost-effectiveness, the criteria of determining the cost-effectiveness is identified minimum control measures and associated costs.

We found some common aspects of costs throughout the case studies for stormwater management by the past researchers.

Typically researchers start with three steps, identifying subject range and BMPs, identifying assumptions, and identifying units of measurement. These three steps gave the researchers and readers clear background information for each case study. Along with these three steps, past researchers also found out the costs that are already being spent in the studied community (cost of baseline stormwater management technique), so that the cost analysis results could be identified as either total cost or additional cost to their current situation.

Some common aspects of cost we found throughout our research on caste studies were: work force/human resources, volunteers and volunteer management, equipment/handout/materials used, time and resources on training sessions time and resources on project development and training sessions, transportation/logistics, and monitoring costs (Leistra, Weiss, & Helman, 2010) (U.S. Environmental Protection Agency, 2007).

Below, we have highlighted four case studies which deal with implementing some of the minimum control measures. Each case study was done in different parts of the United States.

Chittendon County, Vermont

The community of Chittenden had to finance an effective public outreach campaign and implement public education/involvement minimum control measures without exceeding a very limited budget. In 2003, the Vermont Agency of Natural Resources prepared a memorandum, which obligated each of 12 member communities to contribute $5,000 per year for five years to finance the regional outreach campaign. Chittenden County used $20,500 per year to place ads that informed the public about preventing pollution from car washing, gardening, and lawn maintenance (U.S. Environmental Protection Agency, 2007).

Monroe County Stormwater Coalition, New York

The Monroe County Stormwater Coalition in New York has a number of public volunteer programs that can count towards its monitoring activities requirement in the MS4 permit. These volunteer programs consist of groups of citizens that monitor more than 100 miles of streams by having one full-time staff member who coordinates 50 volunteer teams of three to five citizens. Each team adopts a 0.5-mile segment of stream for two years. In preparation for monitoring, each team contacts its local government to learn about the program and their task. Afterwards, a representative from each team attends a two to three hour training session and each team is given a participant's manual. Higher levels of training sessions are also offered for teams that want to improve their skills. (U.S. Environmental Protection Agency, 2007)

Cuyahoga County, Ohio

Cuyahoga County in Ohio has implemented a program that involves inspecting newly installed and existing septic systems to reduce flows of inadequately treated household sewage to storm drain systems and receiving waters. 2,400 failing systems have been replaced and 5,000 have been eliminated by installing sanitary sewers. The Board of Health estimates that 6,500 out of 13,000 systems currently in use are not properly treating household sewage. This program will cost $500,000 per year and employs 17 district sanitarians who are responsible for septic system evaluations and other public health programs. (U.S. Environmental Protection Agency, 2007)

Eugene, Oregon

Eugene, Oregon has developed an outcome-based erosion control program. In 1997, Eugene implemented the Erosion Prevention and Construction Site Management program and requires all construction activity in the city to meet minimum standards to protect water quality. Eugene's program requires all construction projects implement mandatory best management practices (BMPs), which is defined through technically feasible, cost-effective BMPs. According to the United States Environmental Protection Agency (USEPA), a BMP is considered cost-effective when the cost is less than or equal to $1.50 per square foot of distributed area. (U.S. Environmental Protection Agency, 2007)

2.5.3 APPROACHES TO CONDUCTING A COST ANALYSIS

Besides cases for different control measures, we have also studied cases and reports on the details of how some communities carried out their own cost analysis. In Washington DC, amendments governing soil erosion, sediment control, and stormwater management are proposed in addition to the new set of stormwater management requirements (Leistra, Weiss, & Helman, 2010). The proposed amendments acknowledges the negative environmental impact of stormwater runoff in urban environments, and DC adopted low impact development (LID) techniques that can more effectively manage stormwater closer to its source (Id.). The cost analysis compared preliminary proposed regulations with existing regulations, compiled available cost data, interviewed government officials, defined three representative building projects, and estimated in total incremental compliance costs (costs to comply with the proposed regulations that are in addition to the costs that would be incurred to comply with current regulations) (Id.). The study found their incremental cost as a percentage of total cost is low by studying three projects, and also provided detail dollar amount for the cost of all three projects (Id.). They indicated that several factors that introduced uncertainty into their results of analysis include critical cost input and stormwater retention rate assumptions for various management techniques (Id.).

2.5.4 COST-EFFECTIVENESS

The Center for Watershed Protection, a non-profit organization devoted to developing responsible land and water management, has gathered and reviewed available cost and pollutant removal data for 33 urban BMPs in different areas, and “calculated 20-year life cycle costs associated with BMP implementation, including design, construction, land, and operation and maintenance”. Cost-effectiveness values were calculated as cost per pound of stormwater to manage (Center for Watershed Protection, 2013).

Two researchers, King and Hagan of the University of Maryland, have studied the unit planning level stormwater cost estimate per impervious acre treated, and provided total initial costs (pre-construction costs, construction costs, and land costs) and total post-construction costs to find out the average annual costs over 20 years. (King & Hagan, 2011) As mentioned above, a BMP is considered cost-effective when the cost is less than or equal to $1.50 per square foot of distributed area according to USEPA (U.S. Environmental Protection Agency, 2007). Therefore, the results of calculation of total costs including initial stages of construction and post construction over the expected lifespan would be useful for the study of cost-effectiveness according to the cost-effectiveness standards set by the USEPA.

2.6 CONCLUSION

For our project, we evaluated the total cost of implementing the upcoming MS4 permit requirements for four central Massachusetts municipalities. With all of the background knowledge stated above in this chapter, we were able to identify the costs of the upcoming MS4 permit. In the next chapter we present the methods we used to determine the costs associated with the upcoming permit.

3.0 METHODOLOGY

For our project, we evaluated the total cost of implementing the upcoming MS4 permit requirements for four central Massachusetts municipalities. We compared the cost of implementing the permit as part of the Central Massachusetts Regional Stormwater Coalition (CMRSWC), comprised of 30 central Massachusetts municipalities, versus implementing the permit individually. For our project we researched stormwater management costs for the towns of Upton, Oxford, Westborough, and Webster, and conducted a case study of each town. During the course of our project we were in the field either mapping or taking water samples in each of the four towns. During our field work we were able to talk with each town's engineer or Department of Public Works (DPW) director.

In order to accomplish our goal, we worked to achieve the following objectives:

1. Identify the costs that Upton, Oxford, Westborough, and Webster (the case study towns) currently spend in their respective stormwater programs to comply with the 2003 MS4 permit.
2. Identify the new costs towns will incur to comply with the upcoming Massachusetts permit.
3. Evaluate the stormwater management costs separated by control measure
4. Identify the benefits the CMRSWC offers to towns.
5. Compare the costs between implementing the permit individually versus implementing the permit with the help of the CMRSWC.

In the following sections we discuss the specific tasks we completed in order to achieve our objectives

3.1 OBJECTIVE 1: IDENTIFY THE COSTS THAT UPTON, OXFORD, WESTBOROUGH, AND WEBSTER CURRENTLY SPEND

In order to accomplish objective 1, we worked to identify what major activities Upton, Oxford, Westborough and Webster perform to comply with the currently active (2003) MS4 permit requirements. Specifically, we analyzed town budget reports, past financial records, past National Pollution Discharge Elimination System (NPDES) annual reports, and costs of common resources that towns need such as a Global Positioning System (GPS) unit or field testing kit.

After reviewing past reports we interviewed each town in order to acquire cost numbers. We interviewed town engineers, DPW workers, conservation agents, and the heads of the DPWs in each town. Information we looked for included costs of programs they listed in their past NPDES annual reports, costs of municipal tasks such as catch basin cleaning or street sweeping, and estimates for some of the upcoming requirements in the new MS4 permit such as outfall sampling. Sample interview questions can be found in Appendix A.

3.2 OBJECTIVE 2: IDENTIFY THE NEW COSTS TOWNS WILL INCUR TO COMPLY WITH THE UPCOMING MASSACHUSETTS PERMIT

For objective 2, we identified the new costs of the upcoming MS4 permit. Fredrick Civian, Stormwater Coordinator for the Massachusetts Department of Environmental

Protection, believes that the new Massachusetts permit will largely mirror the requirements of New Hampshire's 2013 Draft Permit. Consequently, we used New Hampshire's 2013 MS4 Draft Permit as the basis for our cost assessment. New requirements include outfall and catch basin inspections, outfall sampling, and additional structures that have to be mapped.

After identifying the differences and new requirements in New Hampshire's Draft Permit (see chapter 2.4.1), we needed to find their associated costs. While we were in the field we were able to ask town engineers their estimates on these new requirements. As well as hearing from town engineers, we also received estimates from employees from various consulting companies that specialized in stormwater management such as Tata and Howard, Verdant Water, and Tighe and Bond. Sample interview questions can be found in Appendix A of this report.

3.3 OBJECTIVE 3: EVALUATE THE COSTS WE HAVE INDENTIFIED BY CONTROL MEASURE

For our third objective we looked into each control measure and their associated costs. As stated above, we conducted multiple in-depth case studies of our four case study towns. According to Robert Yin, an established researcher, a case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context (Yin, 1994). We gathered data from archival records such as past stormwater reports, interviews, and participant-observation. For archival records and interviews, we indicate detailed research objects and targets in each of the following sub-sections. For participant observation, we worked in the field of the cast study towns for three days each, to learn the difficulties, resources used, the time needed to complete a task such as mapping or water sampling, and to identify resources that could be shared between towns.

Our organization for each control measure included the following pieces of analysis:

1. Work force/human resources (labor)
2. Volunteer management
3. Equipment/material costs
4. Time and resources on training sessions and project developments
5. Monitoring costs
6. Consulting costs

We analyzed both initial cost and total cost of each over the entire lifespan of a MS4 system. (Leistra, Weiss, & Helman, 2010) (King & Hagan, 2011) (U.S. Environmental Protection Agency, 2007).

To assess the cost of work force/human resources, we considered the salary, insurance and logistics of hiring staff. To assess the cost of volunteer management, we studied the cost or organizing volunteers. For equipment and material costs, we looked into the market price by archival research and seeking quotes; and to assess the cost of time and resources on training sessions and project development, and monitoring costs we considered employee cost, equipment cost, and total time needed to complete an assigned task. We discuss in detail how we studied the costs associated with each control measure in the following sub-sections.

PUBLIC EDUCATION AND OUTREACH

To analyze the cost of implementing the Public Education and Outreach control measure, we found past National Pollution Discharge Elimination System (NPDES) annual reports and project reports for stormwater related projects in each of the four municipalities. We also interviewed consulting companies such as Verdant Water, a consulting company that specializes in stormwater, to find out public education and outreach related costs. A full list of draft interview questions can be found in Appendix A.

As the public education and outreach control measure is about educating the residents on the issues associated with stormwater, we analyzed the practices the case study towns have instituted (if they are in compliance), or might implement (if they are not yet in compliance). Some examples of best management practices (BMPs) for this control measure include distributing brochures or fact sheets to the general public, setting up public signs, and creating a database of relevant materials. For each of the BMPs listed above we investigated the cost of printing materials, paying task force working hours, cost of organizing volunteers, maintenance costs, and operation cost of the database by searching the cost of materials from the archives of previous projects, archives about staff salary level, and websites of related businesses. We received quotes for some of the factors listed above from consulting companies who specialize in stormwater management as well as estimates from various town engineers.

PUBLIC INVOLVEMENT AND PARTICIPATION

To find out the cost of implementing the Public Involvement and Participation control measure, we looked into past stormwater reports, as well as conducted interviews with the municipal employees who have worked on stormwater related tasks. A full list of draft interview questions can be found in Appendix A. We looked into areas of cost which included the cost of organizing workshops, meetings, and volunteer watch groups, as well as developing related training programs and materials.

For the interviews we conducted with municipal employees who have worked on stormwater related tasks, our questions focused on the Public Involvement and Participation control measure, which states that the municipality must make every effort to reach out and engage all economic and ethnic groups, such as holding public meetings/citizen panels, conduct workshops led by volunteer educators, and organized citizen watch groups. The interviews were a semi-structured interview, so the interview contained open-ended questions while we are able to follow our designed set of questions to get the answers on the difficulties and costs of implementing the Public Involvement and Participation control measure. A full list of draft interview questions can be found in Appendix A.

ILLICIT DISCHARGE DETECTION ELIMINATION SYSTEM

This control measure was the most lengthy of the six. Some of the requirements for each municipality are to map their stormwater infrastructure and complete outfall sampling.

In order to deduce each town's approach to detecting and eliminating illicit discharges we conducted interviews with municipal and state workers who have experience with this control measure. We talked with conservation agents, Department of Public Works (DPW) employees, town engineers, and DEP employees with a background in stormwater management. Sample interview questions can be found in Appendix A. Compliance with this control measure will be the most labor intensive for the municipalities, which will add up in costs. While we were out in the field for three days we documented the average time it took to map each location. These locations consist of the catch basins, the outfalls, the pipes, the manholes, and the connections with other MS4s. We used these times and calculated the time it takes to map a catch basin or outfall, and applied it to the cost of mapping MS4 systems with municipal workers or hiring a contractor to map them for the municipality.

We also conducted interviews to discern what equipment is available to the municipality, such as a GPS unit for mapping or specialized catch basin cleaning trucks. We also gathered information on conducting a dry or wet weather sample for an outfall, whether done in house or having the task sub-contracted out.

PRE AND POST CONSTRUCTION SITE RUNOFF CONTROL

In order to conduct the cost of implementing the Pre and Post Construction Site Runoff control measure, we interviewed subject municipal employees and conducted field research. Interviewees included consulting companies such as Tata & Howard, operative officers such as DPW employees and highway workers in municipalities who work on implementing the requirements of this control measure, and town engineers in charge of their towns' respective programs. During the interviews, we gathered information about town's stormwater management plans, including whether they have come up with a standard or universal regulation for enforcing the erosion and sediments control, and how much labor and resources they use for the tasks. A full list of draft interview question can be found in Appendix A. Alongside interviews, we reviewed documents from past NPDES annual reports in order to better understand the cost of implementing these two control measures.

POLLUTION PREVENTION/GOOD HOUSEKEEPING

To find out the cost of implementing the Pollution Prevention/Good Housekeeping control measure, we interviewed consulting companies, town engineers, and DWP workers. This control measure requires employee training on the method to incorporate pollution prevention/good housekeeping techniques. The training materials are available from United States Environmental Protection Agency (USEPA) and other related organizations, but actual training time, manpower, number of employees to be trained are all a concern depending on the specific situation of each town.

During our interviews we asked questions about the current status of employees to be trained, the cost of training, and the cost of various tasks listed below. Tasks include keeping good records of the town's stormwater management program, maintenance for BMPs and stormwater infrastructure, controls for reducing or eliminating the discharge of pollutants, and procedures for the proper disposal of waste. Some examples of ways to reduce pollution through best management practices can be found in section 2.3.2.

3.4 OBJECTIVE 4: IDENTIFY BENEFITS THE COALITION OFFERS TO TOWNS

For this objective examined resources that can be shared among towns. Examples of resources that can be shared include a GPS unit, such as a Leica or tablet, field testing kits, web-based Geographical Information System (GIS) for mapping, and training videos for MS4 maintenance. Pooling these resources may help lower the cost of implementing the MS4 permit. We analyzed documents specific to the CMRSWC and interviewed Tata and Howard, the consulting company that the CMRSWC hired. Through these interviews we were able to discern the rotation schedule for the Leica unit and its cost, cost of purchasing field kits, and the cost of creating and maintaining a web-based GIS for mapping.

3.5 OBJECTIVE 5: COMPARE THE COST OF COALITION VS. INDIVIDUAL IMPLEMENTATION

For our final objective we looked into comparing the cost of implementing the MS4 permit with the help of the CMRSWC against the cost of an individual municipality working to comply with the minimum control measures. This objective was completed by first, finding the cost of implementing the permit individually, then we took out the cost that we identified as a sharable cost that the CMRSWC offered and substituted those costs with the CMRSWC membership fee.

Some of costs the CMRSWC absorbed included the cost of creating a system for stormwater structural mapping, the cost of buying a GPS unit for mapping, and the cost of various training programs for employees.

4.0 FINDINGS CHAPTER

Throughout our project term, we have found many costs that are included in the MS4 permit. Some of these costs are obvious, like the cost of cleaning catch basins, but others are less obvious, like the cost of public education and outreach. The bulk of our research to find these costs comes from information from what towns are doing now to comply with the 2003 municipal separate storm sewer system (MS4) permit. This information comes straight from the town's sources such as town engineers or town department of public works (DPW) workers. Many of the costs have to be estimated because some costs are either not documented or they are not filed under the town's stormwater program. Most towns, through our research, are trying to stay ahead of the curve by attempting to comply with the future permit (to their knowledge of it). If towns are given the green light by town meetings, they are doing their best to plan for the future. Other towns are struggling with funds due to most residents not wanting to pass extra taxes for stormwater management.

4.1 SELECTION OF CASE STUDY TOWNS

To complete the goal of our project, we needed subject towns to study. Upton, Oxford, Westborough and Webster were all selected by our sponsor, the DEP, purely for the fact that the Leica and water sampling kits were scheduled to go there through the coalition rotation. The coalition rotates their materials every two weeks to different towns in the coalition. Although the selection was based on a schedule of supplies, it worked out perfectly in terms of a case study. The towns were unique enough to show the costs of different sized towns and build a valid case study.

4.2 COST COMPONENTS FOR MS4 PERMIT

We studied what the towns are currently working on related to stormwater in the past few years from town's NPDES Phase II MS4 permit annual reports. Based on the activities done by towns before, we have created a table of cost components for the 2003 MS4 Permit. It is necessary to clarify that the programs below were not limited to 2003 MS4 permit requirements. Some towns wanted to be ahead and were running programs according to the 2013 New Hampshire MS4 permit. For example, catchment delineation was not a requirement in the 2003 Massachusetts permit but it is in the 2013 New Hampshire Permit. The table below is an example of our blank spreadsheet for the illicit discharge, detection, and elimination (IDDE) program. A full spreadsheet of every control measure can be found in Appendix B. The programs vary from town to town, so we listed all the programs that each town was doing to complying with the permit and put them into one spreadsheet.

Table 5. Sample cost component spreadsheet

IDDE Program	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Outfall Mapping							
Catch Basin Mapping							
Map Structural BMPs							
Flyover Mapping							
Illicit Discharge Prohibition Ordinance/Bylaw							
Develop IDDE Program							

Outfall Monitoring							
Develop Employee Training Program to Identify Discharges							
Identify Illicit Discharges							
Rank Catchment Area							
Outfall Sampling (Dry)							
Outfall Sampling (Wet)							
Develop Stormwater Management Program Web Based GIS System							
Outfall Research And Planning							
Outfall Inspecting							
Delineate Catchment Area							
Total Cost							

4.3 CASE STUDIES RESULTS: STORMWATER MANAGEMENT COSTS IN THE MUNICIPALITIES

As mentioned in our Methodology chapter, we conducted four case studies on each of the towns we visited for field work. These towns were Upton, Oxford, Westborough, and Webster. While in the towns we worked on mapping in Upton and Westborough, and worked on water sampling in Oxford and Webster. During our time in the towns we were able to meet the town engineer or director of DPW or related contractor or personnel to talk about their current stormwater program cost. Note that no towns meet the entire permit requirements at this moment and the cost values are obtained according to the corresponding town’s expenditure in the fiscal year of 2013. Each town was different in some ways but similar in others, so in order to fully analyze each town we looked into factors that may affect their stormwater program. Factors we were considering include population, area, percent impervious coverage, and median household income.

4.3.1 UPTON

Upton Massachusetts is a small New England town that was founded in 1735. Upton is located in Worcester County along with many other towns (Town of Upton). Upton is a smaller town, with an area of only 21.8 square miles (U.S. Environmental Protection Agency New England, 2010).Of that 21.8 miles, 1.42 square miles are impervious surface, 21.5 square miles are covered by land and about 0.3 square miles of water (U.S. Environmental Protection Agency New England, 2010) (Town of Upton). There are about 7540 residents in Upton which is pretty low for a New England town (Town of Upton). Upton's unemployment rate is 5.9 percent which is lower than the Massachusetts rate of 6.8 percent (Mass.gov, 2014). The median household income for Upton is about $115,625. (United States Census Bureau)

As we stated in methodology chapter, we looked into Upton's National Pollution Discharge Elimination System (NPDES) Phase II MS4 permit annual report and documented all the programs that had been included in their report. Then we interviewed Aubrey Strause from Verdant Water, who is currently the contractor that Upton hired. During the interview, Mrs. Strause provided us cost details for Upton's stormwater programs they implement in order to comply with the MS4 permit. The numbers we received were mostly estimates.

From the initial findings, we have filled out the cost component sheet for Upton based on our study. The detailed sheet could be found in Appendix C of this report. Part of the tasks are one-time tasks while others are yearly tasks, the table below is listing the one-time tasks. Different tasks that involve one-time costs are listed in the second column and are organized by control measures which are indicated in the first column. The third column of the table is the amount that town of Upton spent to complete the corresponding task. The yearly equivalent costs for each task are in the last column, and as the permit has a five-year period of validity, the yearly equivalent cost is simply obtained by dividing the total cost by five.

Table 6. Total one-time cost for Upton

Control Measures	Tasks	Costs [$]	Yearly Equivalent Cost [$]
IDDE Program	Mapping	7,500	1,500
	Illicit discharge prohibition ordinance/bylaw*	8,000	1,600
	Develop employee training program to identify discharges	2,000	400
Construction Site Stormwater Runoff Control	Develop Erosion Control Regulations*	3,000	600
	Develop and implementation site plan review process for sites	2,000	400
	Develop construction inspection program and inspect	10,000	2,000
Post-Construction Stormwater Management	Develop BMP Regulation*	3,000	600
	Develop inspection program of installed BMPs	5,000	1,000
Good House	Municipal SWPPP	1,000	200

Keeping and Pollution Prevention			
Total One-Time Cost		***41,500***	***8,300***

As mentioned, the detailed sheet could be found in Appendix C of this report. We put the total yearly cost with the yearly equivalent of one-time cost together to reach an average yearly cost for 2003 permit for Upton. The table below shows the average yearly cost for Upton for 2003 permit organized by control measure.

Table 7. Total yearly cost for Upton

Control Measures	Costs	Yearly Equivalent Cost [$]
Public Education and Outreach	One-Time Yearly Equivalent	0
	Yearly	6,150
Public Involvement and Participation	One-Time Yearly Equivalent	0
	Yearly	14,500
IDDE Program	One-Time Yearly Equivalent	3,500
	Yearly	0
Construction Site Stormwater Runoff Control	One-Time Yearly Equivalent	3,000
	Yearly	2,000
Post-Construction Stormwater Management	One-Time Yearly Equivalent	1,600
	Yearly	0
Good Housekeeping and Pollution Prevention	One-Time Yearly Equivalent	200
	Yearly	22,000

Total Yearly Cost	52,950

The table above shows the one-time costs for Upton's current work. Upton's yearly cost is fairly low due to minimum compliance with the 2003 permit. The yearly cost of the 2003 permit for Upton was $52,950 (5-year permit). Upton hires contractors to deal with most of their stormwater management. Upton sub-contracts their mapping, catch basin cleaning, and street sweeping.

4.3.2 OXFORD

Oxford is a town in Massachusetts that is part of the Worcester Country. It was first settled in 1686 and was official incorporated as a town in 1713. According to the United States Census Bureau, Oxford has a total area of 27.5 square miles (mi^2). Of this 27.5 mi^2, 0.9 mi^2 is water while the remaining 26.6 mi^2 is land (United States Census Bureau). According to the USEPA's impervious surface cover and watershed map, Oxford has 2.54 mi^2 of impervious surfaces which is about 9% of its area (U.S. Environmental Protection Agency New England, 2010). According to the towns 2013 town report the population of Oxford is 12,302 (Oxford, n.d.). Oxford's median household income, according to the United States Census Bureau is $68,226 (United States Census Bureau).

As stated in our Methodology chapter, we looked through their NPDES Phase II MS4 permit annual report and documented all programs that had been included in their report. We then interviewed the town engineer Sean Divoll for specific costs of each program. Oxford as a town deals with stormwater without a consultant except for their mapping component. They hired an unnamed consultant about three years ago to complete their mapping including the catch basins, outfalls, pipes, and manholes inside and outside of Oxford's MS4 area. The individual broken down control measure costs can be located in Appendix C of this report.

From the initial findings, we have filled out the cost component sheet for Oxford based on our study. Part of the tasks are one-time tasks while others are yearly tasks, the table below is listing the one-time tasks. Different tasks that involve one-time costs are listed in the second column and are organized by control measures which are indicated in the first column. The third column of the table is the amount that the town of Oxford spent to complete the corresponding task. The yearly equivalent costs for each task are in the last column, and as the permit has a five-year period of validity, the yearly equivalent cost is simply obtained by dividing the total cost by five.

Table 8. Total one-time cost for Oxford

Control Measures	Tasks	Costs [$]	Yearly Equivalent Cost [$]
IDDE Program	Outfall Mapping	19,500	3,900
	Catch Basin Mapping	19,500	3,900
	Illicit discharge prohibition ordinance/bylaw*	8,000	1,600
	Develop employee training program to identify discharges	2,000	400
Construction Site	Develop Erosion Control Regulations*	3,000	600
	Develop and implementation site plan	2,000	400

Stormwater Runoff Control	review process for sites		
	Develop construction inspection program and inspect	10,000	2,000
Post Construction Stormwater Management	Develop BMP Regulation*	7,000	1,400
	Develop inspection program of installed BMPs	5,000	1,000
Total One-Time Cost		***76,000***	***15,200***

As mentioned, the detailed sheet can be found in the Appendix C of this report. We put the total yearly cost with the yearly equivalent of one-time cost together to reach an average yearly cost for 2003 permit for Oxford. The table below shows the average yearly cost for Upton for 2003 permit organized by control measure.

Table 9. Total yearly cost for Oxford

Control Measures	Costs	Yearly Equivalent Cost [$]
Public Education and Outreach	One-Time Yearly Equivalent	0
	Yearly	5,000
Public Involvement and Participation	One-Time Yearly Equivalent	0
	Yearly	10,000
IDDE Program	One-Time Yearly Equivalent	9,800
	Yearly	7,000
Construction Site Stormwater Runoff	One-Time Yearly Equivalent	3,000
	Yearly	7,000

Control		
Post-Construction Stormwater Management	One-Time Yearly Equivalent	2,400
	Yearly	0
Good Housekeeping and Pollution Prevention	One-Time Yearly Equivalent	0
	Yearly	77,500
Total Yearly Cost		***121,700***

The table above shows the one-time costs for Oxford's current work. Oxford's yearly cost is fairly low due to minimum compliance with the 2003 permit. The yearly cost of 2003 permit for Oxford was $121,700 (5-year permit).

4.3.3 WESTBOROUGH

The town of Westborough was incorporated in 1717 as the 100th town in Massachusetts, currently with a land area of 21.62 square miles (Town of Westborough, Massachusetts). With 18000 residents and 8895 labor force, the area unemployment rate is 5.3% (The Official Website of the Executive Office of Labor and Workforce Development (ROLWD)). Westborough gets 46 inches of rain, and 56 inches of snowfall per year, compared to the U.S. average of 37 inches of rainfall and 25 inches of snowfall. There are 3.35 square miles of impervious area (15.64% of total area, EPA says total 21.44 square miles) (U.S. Environmental Protection Agency New England). The median household income is $97,535 according to 2008-2012 American Community Survey 5-Year Estimates (U.S. Department of Commerce).

As stated in our methodology, we looked through Westborough's NPDES Phase 2 MS4 permit annual report and documented all the programs that had been included in their report, as well as interviewed an expert in stormwater management. Westborough as a town works on stormwater issues mostly in-house. The numbers we received were mostly estimates. From the initial findings, we have filled out the cost component sheet for Westborough based on our study. The detailed sheet could be found in Appendix C of this report. A subsection of the tasks are one-time costs, and others are yearly tasks, the table below is listing the one-time tasks. Different tasks that involve one-time costs are listed in the second column and are organized by control measures which are indicated in the first column. The third column of the table is the amount that the town of Westborough spent to complete the corresponding task. The yearly equivalent costs for each task are in the last column, and as the permit has a five-year period of validity, the yearly equivalent cost is simply obtained by dividing the total cost by five.

Table 10. Total one-time cost for Westborough

Control Measures	Tasks	Cost [$]	Yearly Equivalent Cost [$]
IDDE Programs	Outfall Mapping	50,000	10,000
	Catch Basin Mapping	50,000	10,000
Total One-Time Cost		***100,000***	***20,000***

As mentioned, the detailed sheet could be found in the Appendix C of this report. We added the total yearly cost with the yearly equivalent of the one-time costs together to reach an average yearly cost for the 2003 permit for Upton. The table below shows the average yearly cost for Westborough for the 2003 permit organized by control measure.

Table 11. Total yearly cost for Westborough

Control Measures	Costs	Yearly Equivalent Cost [$]
Public Education and Outreach	One-Time Yearly Equivalent	2,500
	Yearly	0
Public Involvement and Participation	One-Time Yearly Equivalent	0
	Yearly	0
IDDE Program	One-Time Yearly Equivalent	20,000
	Yearly	0
Construction Site Stormwater Runoff Control	One-Time Yearly Equivalent	0
	Yearly	10,000
Post-Construction Stormwater Management	One-Time Yearly Equivalent	0
	Yearly	0
Good Housekeeping and	One-Time Yearly Equivalent	0

Pollution Prevention	Yearly	55,000
General Staff		220,000
Total Yearly Cost		***307,500***

The reason Westborough is split up differently than the other towns in this report is because the staff labor costs were relatively known but the time for the tasks completed by the staff were unknown. These costs were pulled out and reported differently than the other towns. The general staff is highlighted in the table above. This staff cost is estimated to be at $220,000 a year which includes DPW workers and town engineers salary with respect to estimated time spent on stormwater issues. For example, this salary includes creating bylaws and inspections of construction sites. This is the reason why three of the control measures do not have any costs associated with them. The table above shows the one-time costs for Westborough's current work. Westborough's yearly cost is very reasonable and shows how much labor costs are. The yearly cost of 2003 permit for Westborough was $307,500 (5-year permit). Most of this cost is dealt with in house and most tasks are not subcontracted out.

4.3.4 WEBSTER

The town of Webster is a medium size town in Massachusetts which was founded in 1832 and is located at the Connecticut border. The town's richest asset is the beautiful fresh water, spring fed Lake of Webster (Town of Webster, 2013). According to the 2010 census, the population in Webster was 16767. (Department of Commerce) The total area of Webster is 14.58 square miles which includes 2.15 square miles of impervious area (U.S. Environmental Protection Agency New England, 2010). The median household income from 2008 to 2012 is $48822 (Town of Webster, 2013). As of February 2014, there were 8272 labor force in Webster town and 750 of them were unemployed (Mass gov, 2013). The unemployment rate is 9% (MassGov, 2013).

We looked through Webster's NPDES Phase 2 MS4 permit annual report and documented all the programs that had been included in their report. Then we interviewed the town engineer Scott Charpentier for specific costs of each program. Since Webster contracts almost all of its stormwater management to the consulting firm Tighe and Bond, we had to reference their data for our report. Scott sent us a cost breakdown of Tighe and Bonds tasks they perform for the town. Many of these costs will be greater than most towns because of the fees for the consultant. From the initial findings, we have filled out the cost component sheet for Webster based on our study. The detailed sheet can be found in Appendix C of this report.

Because some of the tasks are one-time costs while others are yearly tasks, we had to find out how to make the one-time costs into yearly costs. The table below lists the one-time tasks. Different tasks that involve one-time costs are listed in the second column and are organized by control measures which are indicated in the first column. The third column of the table is the amount that the town of Webster spent to complete the corresponding task. The yearly equivalent costs for each task are in the last column, and as the permit has a five-year period of validity, the yearly equivalent cost is simply obtained by dividing the total cost by five.

Table 12. Total one-time cost for Webster

Control Measures	Tasks	Cost [$]	Yearly Equivalent Cost [$]
Public Education and Outreach	Develop appropriate material (i.e. pamphlets)	2,400	480
Public Involvement and Participation	Develop methods to gauge outreach effectiveness	1,500	300
IDDE Program	Outfall Mapping	45,000	9,000
	Catch Basin Mapping	45,000	9,000
	Map Structural BMPs	12,000	2,400
	Flyover mapping	15,000	3,000
	Illicit discharge prohibition ordinance/bylaw*	11,000	2,200
	Develop IDDE program	33,000	6,600
	Develop employee training program to identify discharges	10,000	2,000
	Rank catchment areas	8,500	1,700
	Develop stormwater management program web based GIS system	22,000	4,400
Construction and Post-Construction Site Stormwater Runoff	Develop Erosion Control Regulations*	10,000	2,000
	Review existing design standards with respect to incorporating Low Impact Development	4,000	800
	Ranking of BMP effectiveness	8,000	1,600
	Develop construction inspection program and	10,000	2,000

Control	inspect		
	Permit review	3,000	600
Good House Keeping and Pollution Prevention	Develop written procedures for operation and maintenance for municipal activities	7,000	1,400
	Municipal SWPPP	7,000	1,400
Total One-Time Cost		***254,400***	***50,880***

As mentioned, the detailed sheet could be found in the Appendix C of this report. We put the total yearly cost with the yearly equivalent of one-time cost together to reach an average yearly cost for the 2003 permit for Webster. The table below shows the average yearly cost for Webster for the 2003 permit organized by control measure.

Table 13. Total yearly cost for Webster

Control Measures	Costs	Yearly Equivalent Cost [$]
Public Education and Outreach	One-Time Yearly Equivalent	480
	Yearly	2,000
Public Involvement and Participation	One-Time Yearly Equivalent	300
	Yearly	4,400
IDDE Program	One-Time Yearly Equivalent	40,300
	Yearly	107,500
Construction Site and Post-Construction Stormwater	One-Time Yearly Equivalent	7,000
	Yearly	22,000

Management		
Good Housekeeping and Pollution Prevention	One-Time Yearly Equivalent	2,800
	Yearly	49,000
Total Yearly Cost		***235,780***

The table above shows the one-time costs for Webster's current work. Webster's yearly cost is very reasonable especially since they have been very proactive in complying with future permits. They are working on doing the testing and marking of outfalls. The yearly cost of 2003 permit for Webster was $235,780 (5-year permit). Although almost all stormwater activities are subcontracted out, Webster's yearly costs are very reasonable compared to the other towns studied.

4.4 EXPECTED COSTS UNDER THE NEW PERMIT

As most municipalities know, there is an expected new MS4 permit to be issued soon. Through our study of how towns comply now and information from experts, we have come up with expected costs of town's compliance with the new permit. For the purposes of our report, we have assumed that the new permit will be very similar to the 2013 New Hampshire MS4 draft permit.

For all the towns studied, they will have to complete many additional future activities, including dry/wet weather inspections and outfall monitoring/sampling. Along with these new tasks, many of the other control measures have more rigorous costs associated with the new permit. For example, the public education and outreach program control measure requires the municipality to send two fliers in the first year to residents, industries and others and eight total in the permit term. This will add cost to each town because these towns are not completing this specific task. We have estimated the costs of these additional future costs in each of the sections below. Overall municipalities will have to implement the following new actions:

Public Education and Outreach

One of the large programs the municipalities must adopt is to send out fliers to four major groupings of individuals. This program will be slightly costly and through our research we expect each town to pay between $5,000 and $10,000 depending on how much work each municipality will put into this. Much of this cost will be to pay for labor to create and distribute education materials.

Public Involvement and Participation

For Public Involvement and Participation minimum control measure, towns need to provide opportunities for the public to get involved in the process of reviewing and implementing the stormwater management plans. Such involvement activities need to follow state public notice requirements. The towns also need to report on the activities undertaken using various ways. All the minimum requirements don’t need additional material cost. All the additional cost comes in to the staff time. From our interviews of our case studies, our research group estimates such activities would increase the cost of this control measure by $1,000 for most cases.

Illicit Discharge Detection and Elimination Program

This control measure will be most costly. Every town will have to complete their mapping of stormwater structures, outfall monitoring/sampling and dry/wet weather inspections. The mapping will range from $25,000 to $90,000 if the municipality has not mapped at all. Most of the towns we have studied are done with their mapping or in the process of it. The outfall sampling estimate will cost $170 per outfall. This total will add up quickly because most towns have over 200 outfalls. Also, the dry/wet weather inspections will cost around $20 per structure depending on how quick the inspector works. These inspections are only labor intensive and are estimated depending on how long it takes to do one inspection. Overall, staff time will increase for outfall monitoring and many other tasks in this control measure.

Construction Site Stormwater Runoff Control

For this control measure will not be too costly in terms of material cost. The construction site stormwater runoff control program will be more costly before because it is more specific. There are not too many regulations but we expect municipalities will have to spend more time on the inspection side. We expect municipalities will spend between $1,000 and $5,000 more on their programs.

Post-construction Stormwater Management

For Post-construction Stormwater Management control measure, towns need to either develop and enforce or keep enforcing a post-construction stormwater management program. For the developing cost, it typically ranges from $8,000 to $12,000 according to our case studies for a five-year permit.

Good Housekeeping and Pollution Prevention

This control measure will be very expensive for towns to comply with. The permit calls for more street sweeping and catch basins. Specifically for the catch basin cleaning, municipalities must expect to spend around twice as much as before because cleaning is expected to happen twice a year. Most municipalities only clean once a year now. For street sweeping, towns will need to document how much they sweep and how often they complete it. The street sweeping will have to occur more so we expect the cost to increase about 20% more.

4.4.1 UPTON

For the upcoming permit, Upton will have to continue mapping their structures. One major structure that many towns are leaving out is their best management practices (BMPs) such as retention ponds or grass swales. Along with most towns, Upton does not have most of their BMPs located. The reason for this is that when new residential developments are built, the construction company builds BMPs such as retention ponds and does not communicate with the town that they built a retention pond and it is now the town's job to maintain it. Towns will have to locate and maintain these BMPs.

Another factor that is in the new permit, towns have to conduct outfall and catch basin inspections. According to our research and interviews with various consulting companies, we estimate that this will cost about $10,000-$12,000. Along with inspections, towns will need to conduct dry and wet weather sampling of outfalls to test for pollutants such as ammonium, surfactants, and bacteria from a septic system. We estimate that this will cost about $7,500 for each weather condition for a total of $15,000 for all sampling. For the upcoming permit, these samples have to be sent into labs to test for bacteria, surfactant, ammonia, chlorine and phosphorous. According to Mrs. Strause's quote from a lab, the cost would be about $170 for testing each sample. In the finalized cost sheet we put in the appendix, we use $190 per outfall instead of $170 because there would be $20 outfall inspecting fee. For Upton's current street sweeping and catch basin cleaning, such tasks are sub-contracted out and are expected to have to spend about five times of what they are spending now.

Table 14. Expected cost for Upton

Control Measures	Costs	Yearly Equivalent Cost [$]
Public Education and Outreach	Current Cost	6,150
	Expected Cost to Comply	10,000
Public Involvement and Participation	Current Cost	14,500
	Expected Cost to Comply	15,500
IDDE Program	Current Cost	3,500
	Expected Cost to Comply	33,000
Construction Site Stormwater Runoff Control	Current Cost	5,000
	Expected Cost to Comply	10,000
Post-Construction Stormwater Management	Current Cost	1,600
	Expected Cost to Comply	3,000

Good Housekeeping and Pollution Prevention	Current Cost	22,200
	Expected Cost to Comply	80,000
Total Current Yearly Cost		***52,950***
Total Expected Yearly Cost		***151,500***

For every control measure, additional costs will be present. This is because of the new tasks in the permit will cost labor and materials. We estimate for the public education control measure that the cost will be about $10,000 total due to the labor needed to create and distribute the fliers sent to groups of people. The additional costs in the public involvement and participation are that towns must do more to post their stormwater information. We estimate on average that each town will need to spend about a $1,000 more each year on this control measure. For the additional costs in the IDDE control measure, we estimate that towns will spend much more than they are now. We expect Upton to spend about $30,000 more because of the costs of sampling, mapping, and inspections. For the construction site control measure we estimate Upton to spend about $5,000 more on labor, inspections, and bylaw creation. For the post construction control measure we expect Upton to spend about $1,000 on labor. For the good housekeeping control measure we expect Upton to spend about $60,000 more each year. This is because they had such a low given cost for street sweeping and catch basin cleaning that we assumed they would need to spend about 5-10 times more to fully comply. With the cost given, we can only assume that the cost is much greater then what is done now. Overall, we estimate that Upton will have to spend almost 3 times as much as they currently do to be able to comply with the upcoming permit.

4.4.2 OXFORD

In order to comply with the upcoming permit, Oxford will have to implement new programs such as outfall sampling, outfall inspections, and catch basin inspections. Currently Oxford does not have a program for inspecting and sampling and most of the towns we interviewed did not as well. According to our research and our interviews with various consulting companies we estimate that outfall inspections will cost towns $10,000-$12,000 depending on the number of outfalls they have. We can assume from our field work that each stormwater structure takes about 10-15 minutes to complete the inspection and travel to the next structure. We figure the average consulting charges about $100 an hour so you can figure that Oxford will spend about $40,000 to complete all inspections. This means that Oxford will spend about $8000 a year during the permit term on stormwater infrastructure inspections. For complying with the 2013 MA MS4 permit, towns will have to send samples into labs to test for bacteria, surfactants, ammonia, phosphorous and chlorine. According to data collected in Upton, the cost would be $170 for each sample. We assume that the new permit would require municipalities to finish their outfall sampling in five permit years. The town of Oxford has 289 outfalls, so it would cost Oxford $49,130 to finish all the outfall sampling. The yearly cost for Oxford on outfall sampling would be $9,826 each year. In the finalized cost sheet we put in the appendix, we use $190 per outfall instead of $170 because there would be $20 outfall inspecting fee. Along with Oxford, most towns do not have all of their BMPs located. According to Sean Divoll, it will cost roughly $2,000 per BMP to clean and maintain the BMPs that are in good shape while BMPs that are in poor shape can cost an upwards of $10,000 and require a consultant to clean out.

Table 15. Expected cost for Oxford

Control Measures	Costs	Yearly Equivalent Cost [$]
Public Education and Outreach	Current Cost	5,000
	Expected Cost to Comply	10,000
Public Involvement and Participation	Current Cost	10,000
	Expected Cost to Comply	11,000
IDDE Program	Current Cost	16,800
	Expected Cost to Comply	40,000
Construction Site Stormwater Runoff Control	Current Cost	10,000
	Expected Cost to Comply	15,000
Post-Construction Stormwater Management	Current Cost	2,400
	Expected Cost to Comply	3,500
Good Housekeeping and Pollution Prevention	Current Cost	77,500
	Expected Cost to Comply	90,000
Total Current Yearly Cost		***121,700***
Total Expected Yearly Cost		***169,500***

For every control measure, additional costs will be present. This is because of the new tasks in the permit will cost labor and materials. We estimate for the public education control measure that the cost will be about $10,000 total due to the labor needed to create and distribute the fliers sent to groups of people. One additional cost in the public involvement and participation is that towns must do more to post their stormwater information. We estimate on average that each town will need to spend about a $1,000 more each year on this posting. For the additional costs in the IDDE control measure, we estimate that towns will spend much more than they are now. We estimate Oxford to have to spend about $23,000 more because of the cost of sampling and inspections. For the construction site control measure we estimate Oxford to spend about $5,000 more on labor, inspections, and bylaw creation. For the post construction control measure we expect Oxford to spend about $1,000 on labor. For the good housekeeping control measure we expect Oxford to spend about $12,000 more each year. We do not expect Oxford to have to spend more on catch basin cleaning due to firsthand experience inspecting catch basins in Oxford. We do expect Oxford will need to continue street sweeping and documenting debris pickup. This will take time and will be a labor cost. Overall, we estimate that Oxford will have to spend about 40% more than they currently do to be able to comply with the upcoming permit.

4.4.3 WESTBOROUGH

In order to comply with the upcoming permit, Westborough will have to implement new programs such as outfall inspections, catch basin inspections and outfall sampling. These programs are not in place yet and will have to be included in their future stormwater costs. According to our research and our interviews with various consulting companies we estimate that outfall inspections will cost towns $10,000-$12,000 depending on the number of outfalls they have. Catch basin inspections will cost about the same (10-12 thousand) and also depends on how many catch basins a town has. For the upcoming permit, samples need be sent into labs to test for bacteria, surfactant, ammonia, chlorine and phosphorous. Outfall sampling using this method would cost about $15,000 with wet weather and dry weather sampling costing $7,500 each. According to information gathered in Upton, we estimate the cost to be $170 for each sample. In the finalized cost sheet we put in the appendix, we use $190 per outfall instead of $170 because there would be $20 outfall inspecting fee.

Other new programs that will be associated with Westborough include increasing public education and public involvement. Westborough did not have exact estimates to share with each control measures. We were however, given an estimate for the expense of total labor for Westborough. This can be seen in the "General Staff" section in the table below.

Table 16. Expected cost for Westborough

Control Measures	Costs	Yearly Equivalent Cost [$]
Public Education and Outreach	Current Cost	2,500
	Expected Cost to Comply	2,500
Public Involvement and Participation	Current Cost	0
	Expected Cost to Comply	0
IDDE Program	Current Cost	20,000
	Expected Cost to Comply	35,000
Construction Site Stormwater Runoff Control	Current Cost	10,000
	Expected Cost to Comply	10,000
Post-Construction Stormwater Management	Current Cost	0
	Expected Cost to Comply	0
Good Housekeeping and Pollution Prevention	Current Cost	55,000
	Expected Cost to Comply	70,000

Current General Staff	220,000
Expected General Staff	300,000
Total Current Yearly Cost	***307,500***
Total Expected Yearly Cost	***417,500***

For every control measure, additional costs will be present. This is because of the new tasks in the permit will cost labor and materials. For the additional costs in the IDDE control measure, we estimate that towns will spend much more than they are now. We estimate Westborough to have to spend about $15,000 more because of the costly sampling and inspections. For the good housekeeping control measure we expect Westborough to spend about $15,000 more each year. We do not expect Westborough to have to spend more on catch basin cleaning. We do expect Westborough will need to continue street sweeping and documenting debris pickup. For the General staff labor cost, we expect Webster to have to spend about $80,000 more because of all the new programs in the permit. Through our interview and time at Westborough, we estimate that they will have to spend much more time on stormwater related activities. Overall, we estimate that Westborough will have to spend about 35% more than they currently do to be able to comply with the upcoming permit.

4.4.4 WEBSTER

For the upcoming permit, Webster will have to do more testing and inspections. Webster mainly uses a consulting firm, Tighe and Bond, to fulfill their requirements. The new testing will be more costly because the town must send samples into labs which can be very expensive with many outfalls. For the upcoming permit, these samples are needed to be sent into labs to test for bacteria, surfactant, ammonia, phosphorous and chlorine.

According to our research and interviews with various consulting companies, we estimate that testing will cost about $15,000 for a total with $7,500 spending on dry weather sampling and another $7,500 spending on wet weather sampling. According to data obtained from Aubrey Strauss, the cost will be $170 for each sample. In the finalized cost sheet we put in the appendix, we use $190 per outfall instead of $170 because there would be $20 outfall inspecting fee. Overall, Webster will only have to adapt a few new programs since its consulting firm does most of their stormwater work. The consulting firm has been doing a lot of work recently on programs that are in the future program and not in the one in place now.

Table 17. Expected cost for Webster

Control Measures	Costs	Yearly Equivalent Cost [$]
Public Education and Outreach	Current Cost	2,480
	Expected Cost to Comply	7,000
Public Involvement and Participation	Current Cost	4,700
	Expected Cost to Comply	5,700
IDDE Program	Current Cost	147,800
	Expected Cost to Comply	180,000
Construction Site and Post-Construction Stormwater Management	Current Cost	29,000
	Expected Cost to Comply	32,000
Good Housekeeping and Pollution Prevention	Current Cost	51,800
	Expected Cost to Comply	75,000
Total Current Yearly Cost		***235,780***

Total Expected Yearly Cost	***299,700***

For every control measure, additional costs will be present. This is because of the new tasks in the permit will cost labor and materials. We estimate for the public education control measure that the cost will be about $5,000 more due to the labor needed to create and distribute the fliers sent to groups of people. The additional costs in the public involvement and participation are that towns must do more to post their stormwater information. We estimate on average that each town will need to spend about a $1,000 more each year on this control measure. For the additional costs in the IDDE control measure, we estimate that towns will spend much more than they are now. We estimate Webster to have to spend about $30,000 more because of the costly sampling and inspections. For the construction site control and post construction control measure the measure we estimate Webster to spend about $3,000 more on labor, inspections, and bylaw creation. For the good housekeeping control measure we expect Webster to spend about $23,000 more each year. We do not expect Webster to have to spend much more on catch basin cleaning. We do expect Webster will need to continue street sweeping and documenting debris pickup. This will take time and will be a labor cost. Overall, we estimate that Webster will have to spend about 27% more than they currently do to be able to comply with the upcoming permit.

4.5 BASELINE COSTS

For each town studied, there will be a decided baseline cost for the town to comply with the expected MS4 permit. This includes all expenses except those which are singular to one town. The idea is to break out varying costs for the town and find actions that are the same for the towns studied. Baseline costs include tasks that each town will have to implement but the cost will not vary between the towns. Tasks we identified as baseline cots include an ordinance or bylaw to prohibit illicit discharge or educating the public about the adverse effects stormwater can have on our environment. The discussion in this section is not specific to any town; rather, it serves as a general case guideline, assuming the towns are going to meet the minimum compliance requirement of 2013 New Hampshire Draft MS4 Permit. For the towns we have worked with, the baselines costs are included in the public education and outreach, public involvement, construction site runoff control, and post construction stormwater management.

Table 18. Baseline costs

Control Measure	Costs [$]			
	Upton	Oxford	Westborough	Webster
Public Education and Outreach	10,000	10,000	10,000	7,000
Public Involvement and Participation	15,500	11,000	0	5,700
IDDE Program	33,000	40,000	35,000	180,000
Construction Site Runoff Control	10,000	15,000	10,000	32,000
Post Construction Stormwater Management	3,000	3,500	0	
Good Housekeeping and Pollution Prevention	80,000	90,000	70,000	75,000
General Staff	N/A	N/A	300,000	N/A
Total Cost	143,700	169,500	417,500	299,700

From this chart, it can be seen that public education and outreach, the costs are similar and it is up to the town how much they need to spend. Looking at the chart below for potential deciding factors, we can see that there is basically no correlation between the cost and different factors. We estimate that for the new permit, most towns will have to spend between $6,000 and $10,000 depending on how thorough they want to be with their public education. Benefits of spending more for public education include people that originally did not know that MS4s discharge into nearby waters instead of going to a treatment facility first will stop illicit discharges such as throwing pet waste into catch basins, which will decrease the cost of the town's IDDE program.

Public participation and involvement also varies depending on how involved you want the community to be. Other than Westborough, we can see that this control measure can cost between $5,000 and $15,000. Westborough does not have cost numbers for each control measure so some of the cost is absorbed in their general staff section.

The pre and post construction site runoff fluctuates between each town. Westborough does not have anything documented and Webster was difficult to separate the costs between the pre and post construction control measures were combined on the reporting. We estimate that to comply with pre-construction, it will cost between $12,000 and $18,000. Post construction stormwater management is not recorded by Webster and Westborough but Oxford and Upton have a range around $7,000 to $8,000 for this control measure.

We estimate that the baseline cost that each town will have to pay for the new permit is as follows:

- $6,000-$10,000 for public education and outreach
- $10,000-$15,000 for public involvement

- $12,000-$18,000 to create an ordinance for sediment control for construction sites and have someone inspect the BMPs present within the sites while they are under construction
- $7,000-$10,000 to have someone continue to inspect the BMPs after construction is finished
- $6,000-$10,000 to create a bylaw or ordinance for detecting and eliminating illicit discharges

The next section describes the varying costs which are costs that will vary between towns.

4.6 VARYING COSTS

After a baseline cost is established, the next step is to take out varying costs for each town. Costs such as stormwater system maintenance, BMP maintenance, and system mapping can vary greatly by town depending on population or area.

One of the major varying costs is replacing pipes and catch basins. For the town of Auburn, in the fiscal year 2014 they reported that they will spend $162,000 on replacing pipes and catch basins. For the town of Westborough, they expect to pay up to $120,000 to change all of their piping from corrugated metal to either cement or plastic. These costs will be semi-yearly in that towns will replace piping and catch basins within a set amount of time, say 20 years, and once their problem pipes and catch basins are replaced they will not have to spend money until the current pipes and catch basins need to be replaced again.

Another varying cost for towns is BMP maintenance. Some towns have been active in cleaning and maintaining their BMPs while others do not even know they have them. In Westborough, they estimate they spend about $16,000-$20,000 a year on retention pond cleaning. On the other hand, Shrewsbury, a town we interviewed with but did not include in our case study, estimated that they will spend about $10,000 per retention pond in order to properly clean them and stated that they had over 100 retention ponds that have not been actively cleaned or maintained.

Overall, the major varying costs are in the IDDE and pollution prevention and good housekeeping control measures. According to Table 18, we pulled out these control measures to create another table below.

Table 19. Varying costs based on control measures

Control Measure	Costs [$]			
	Upton	Oxford	Westborough	Webster
IDDE Program	33,000	40,000	35,000	180,000
Good Housekeeping and Pollution Prevention	80,000	90,000	70,000	75,000
General Staff	N/A	N/A	220,000	N/A

For the towns shown, these control measures are widely different.

For the IDDE control measure there are major differences in the stormwater structural mapping, outfalls inspections, and outfall sampling. For the town of Oxford, they spent $39,000 on mapping all their stormwater structures which includes a $25,000 premium for an unnamed consultant and a DPW worker to map all of the catch basins, outfalls and storm drains for 3 months. In Webster, they spent about $90,000 for the mapping each year with Tighe and Bond. One reason for the difference of costs could be the number of stormwater structures in the towns is different across the board.

A major difference between the good housekeeping control measures across the towns is street sweeping and sand/salt maintenance. For the town of Upton, they spend about $5,500 each year on street sweeping but the town of Oxford spends $47,500 which is clearly much more. The street sweeping in Upton is done by a consultant but the street sweeping done in Oxford is done in house. These costs are relative to each town depending on how much mileage of roads are present.

4.7 SHARED COSTS

With the impending heightened costs of the new MS4 permit, many towns have prepared by forming coalitions to share resources. The Central Massachusetts Regional Stormwater Coalition (CMRSWC) works with thirty towns to comply with the permit. The CMRSWC is composed of many different people including DPW workers, town engineers, and consultants. The coalition has received grants in the past to help with the total cost of the coalition. With this money and money from yearly membership fees they have worked together to help each other comply with the permit. Some of the shared costs that the coalition covers are the Leica units, maintenance on tools, one-on-one support, People GIS (one geographic informational system) training, sustainable financing and access to the CMRSWC website. These specific costs can be seen in the chart below.

Table 20. Coalition costs vs. individual cost

Program	Costs [$]		
	Coalition	Average cost for towns in the coalition	Average cost for towns ***not*** in coalition
Tata & Howard invoices	159,500	5,317	5,317
People GIS	52,875	1,762	**1,762**
Central Massachusetts Regional Planning Commission	1,857	62	0
Virtual Town Hall Website Development and Hosting	9,481	316	9,481
Graphic Designer	500	17	0
Public Education and Outreach Tools	2,612	87	2,612
Tablet Devices (13)	7,975	613	613
Water Quality Meters and Kits	13,945	465	465
Mapping/GIS Tools (includes two Leica's)	55,113	1,837	18,516
Total	***302,358***	***10,476***	***36,766***

People GIS agreement is assumed to be written for 30 municipalities, so we assumed that this amount would divide by 30 to find price per town outside the coalition. This could not be the case so we took the dividend as the lowest amount possible

To obtain the data in the “Coalition” column we received information from Aubrey Strauss a coalition member. In the “average cost in coalition” column we analyzed how much each town is paying per coalition task by dividing all the tasks by 30 (since there are 30 municipalities in the coalition). The only exception is the “Tablet Devices” row which we divided the total by 13 since there were only 13 devices purchased and set up. To obtain the “Cost for singular town” column we estimated all costs that a town outside the coalition would have to pay to get the same services. Many of these are the same as the previous column except when prices drop to zero because those costs are relative to only the coalition. The main price jump in this column was the price for the Leica and web access. Since the coalition owns two Leica’s, we found the price for one Leica, the web access jetpack and web access for the Leica. This added up to be $18,516.03 which is much more than the average price per town which is $1,837.09.

Without the coalition, each town would be responsible for most of these costs in the table. We can clearly see that to get the same results as you would in the coalition, towns would need to spend $36,766.20. This is much more than the value of the services which is $10,476.23 when the resources are shared in the coalition. The coalition has a membership fee of about $4,000 which is repaid with $10,476.23 in services. This value is a great deal because municipalities are basically receiving over $6,000 in services for free. Also, the $4,000 membership fee is much less than the $36,766.20 to pay for the services by not sharing resources. This means municipalities are saving around $32,000 by being a member of the coalition.

4.8 ADDITIONAL COSTS IN MS4

For the purposes of our project, we have mainly looked the six control measures as our major costs of the MS4 permit. There are other costs that are listed in the MS4 permit but were not specifically covered by the towns we have done research on. One of these is sanitary sewer overflow (SSO). This happens when the stormwater sewer and the septic lines are in the same pipe. When there is a major storm, the untreated sanitary wastewater discharged from a municipal sanitary sewer to a stormwater sewer caused by overflow. This issue is expensive to fix because towns need to redo there piping and attempt to get rid of the septic material in the water supply. The costs involved in solve the SSO problem include the cost for identifying all the SSOs, recording date and time of each known SSO occurrence and implement measures to control these sources so they are no longer significant contributors of pollutants to the MS4 or eliminate them entirely.

Another cost in the MS4 permit which we did not look into is a TMDL or total maximum daily load of a river or water supply. This is a calculation of how much pollutants a water body can naturally sustain without being considered polluted or unsafe. This can cost a lot of money because a lot of research must be conducted and the water supply must stay relatively unpolluted. For most towns we have studied, they do not have to deal with TMDL because they do not have impaired water. In the town of Webster, the consulting company Tighe and Bond does work on the Long Island Sound TMDL for Webster. They charge Webster approximately $6,200 annually on this task. TMDL can be more expensive depending on the problem and the size of the water body impaired.

4.9 COST DRIVERS

In order to possibly derive a way to find an overall cost for other towns, we must find what drives cost for complying with the permit. Many different factors drive cost. These are, but not limited to, impervious surface area, number of catch basins/outfalls, and linear miles of road. All of these contribute to cost greatly. For our project, we have been limited to the factors of impervious area cover, total area, and population of each town. The chart below shows some of these factors.

Table 21. Deciding factors

Potential Deciding Factors	Units			
	Upton	Oxford	Westborough	Webster
Total area [square miles]	21.8	27.5	21.62	14.58
Impervious surface area [square miles]	1.42	2.54	3.35	2.15
Number of catch basins		1473		
Number of outfalls		289		
Linear length of pipe [miles]		30		
Population	7,540	12,302	18,000	16,767

Through simple graphing, we have compared these factors for each town to the cost found that each town spends. The graph below shows the relationship.

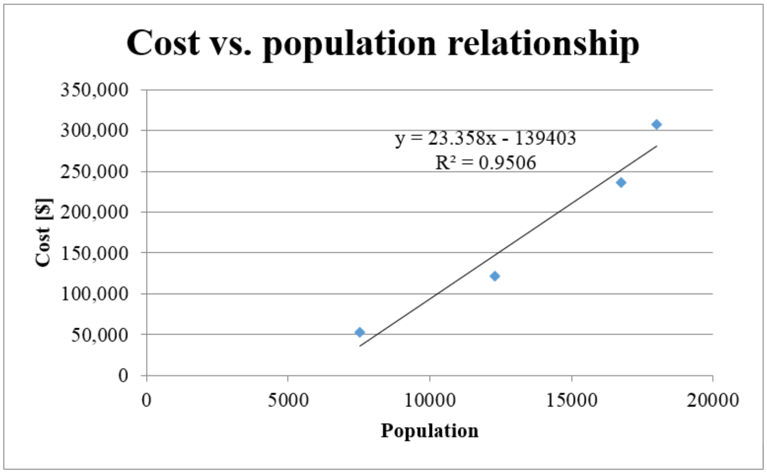

Figure 4. Cost vs. population relationship

The population was set as the independent variable and cost as the dependent variable. This is because we want to see what drives costs. This relationship is relatively linear and the data points are closer to the line of best fit compared to the other charts. The other factor charts can be found in Appendix D.

We have found that population creates the most linear relationship between a factor and compliance cost. Now moving forward, we will find the relationship between the population and the future costs. The chart below shows this.

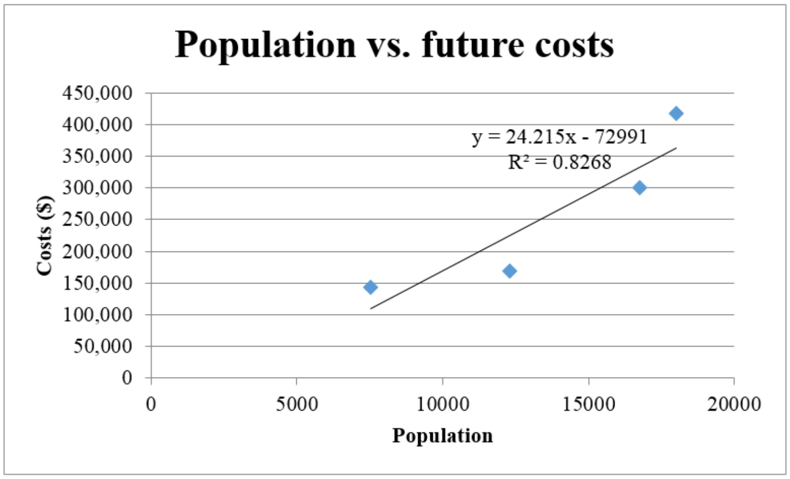

Figure 5. Population vs. future costs

This chart is very similar to the other population chart, which is something we would expect. The formula on the chart of y = 24.215x – 72991 we believe can be administered to other small MS4 towns as well. The "x" variable is the town's population and we believe that this formula can give other towns a ballpark estimate of their expected cost to comply.

4.10 FIELD WORK AND TECHNICAL ASSISTANCE

During our four weeks of field work, we collected raw data like how many stormwater structures a team can map per day and some issues with the mapping tools that every town might encounter when mapping with the Leica unit. During our interview with stakeholders and consulting companies, we found there were several practical problems for towns to implement the MS4 permit and some facts about the towns in coalition perspective.

For mapping catch basin and man-holes, two members of our team mapped 55 catch basins and 37 man holes in one day. The outfall mapping was really hard for us since many outfalls were located behind some residents' back yard. As a result, a two-member group only mapped 12 outfalls in one day. Outfall and catch basin sampling will take a little bit longer than mapping. For sampling one catch basin or outfall, it will take a four-man group about 20 minutes to conduct a full screening test including ammonia, detergent, chlorine, turbidity, conductivity, temperature, pH, and salinity.

According to the town of Shrewsbury, the town has a large number of locations bordering with a state highway, and according to MS4 permit, the town is required to inspect all outfalls. For example, if a pipe crosses a state highway several times, the town is required to sample multiple adjacent locations of the pipe even though the flow remains the same. This is causing problems of redundant sampling.

Furthermore, when we interviewed towns, we found out that there is still some need of training for the sampling kits such as ammonia testing kits and turbidity testing device. Training for mapping devices such as the Leica unit and tablet is also insufficient. It would take towns much less time for sampling and mapping if they were familiar with the tools.

4.10.1 LIMITATIONS

For this project, there was no large limitation that has set us back in the process of our project. One limitation for our project was the fact that the Leica unit was not working properly. Since the Leica was not functioning in either town, we were forced to use a tablet GPS and receive inaccurate results. These results were able to be changed so we fixed then to be on the correct position.

Another limitation for our projects is that we don't completely know the future costs of complying with the specifics of the permit. These tasks are not being done at this point so it can be difficult to get accurate estimates for each task.

Another limitation of the project is that most costs we have are estimates from professionals. Although these estimates are very reasonable, they still are not as desirable as reported budget numbers. These estimates are still very much valid, but for a more in-depth project might require more reporting.

4.11 SUMMARY

For all of our costs we know that there are some uncertainties. All of our labor costs are estimates from either town engineers or consulting companies. Most of the costs we received from towns did not include labor costs. An example would be if a town estimated that they spent $5,000 on catch basin cleaning but did not include their DWP workers' wages in the estimation. On their annual report it would state that they spent $5,000 but in reality it cost them about $30,000 because of labor.

Other estimates in our cost analysis include the cost of implementing programs that are required for the upcoming Massachusetts permit. Out of all of our towns, Webster was the only town that had an estimate for outfall monitoring, sampling, and inspecting. Because of this, we based our estimates on upcoming costs on the information from Webster and information from the USEPAs study on different towns in the Charles River

Watershed. One factor we had to take into account was that Webster used a consultant to do most of their stormwater program, so their costs are higher than if they were to implement their programs with municipal workers instead.

We hope that with this information, towns will be able to identify their costs and prepare for the upcoming permit. In the next chapter, Recommendations, we will list our recommendations for towns that we found and recommendations for our sponsor, MassDEP, for additional projects.

5.0 RECOMMENDATIONS CHAPTER

In this chapter, we offer our recommendations for municipalities to reduce the cost of stormwater management. An example of this is sharing resources among towns of the coalition. Also in this chapter, we recommend future projects or work such as conducting a study on total maximum daily loads (TMDLs) and funding mechanisms.

5.1 RECOMMENDATIONS FOR MUNICIPALITIES TO REDUCE THE COST OF STORMWATER MANAGEMENT

Sharing resources is a very easy way for municipalities to reduce the cost of stormwater management. For many items, municipalities can join in large groups as a coalition to lower the costs, e.g. joining the CMRSWC. Outside of sharing resources via a coalition, if two or more municipalities can share certain resources within themselves as a smaller group, it could also lower the cost.

Another recommendation for towns would be to do testing, inspection and cleaning all simultaneously. Accomplishing multiple tasks within the minimum required time increases the cost-efficiency. For the cleaning of the catch basins and testing, we suggest they be done by schedule. Also for outfall sampling and catch basin cleaning, we suggest that testing and cleaning could be conducted at proper times of the year taking into fact the town's situation including storms, sand build up, and car traffic on the road or street.

We also recommend that the MS4 permit drafter make a note in the draft permit that towns do not have to sample outfalls several times once the respective flows have been identified to be the same. According to the town of Shrewsbury, the town has a large number of places bordering with a state highway, and according to the MS4 permit, the town is required to inspect all outfalls. For example, if a pipe crosses a state highway several times, the town is required to sample multiple adjacent locations of the pipe. This will cause problems because of redundant sampling and will be a waste of resources and time for the town.

For towns that have stormwater facilities and infrastructure mapped without elevation (one factor to comply with the new permit), towns can potentially add elevation by using GIS tools and verify by field work.

CMRSWC should have more frequent training for coalition towns on sampling and Leica use. Each town needs to have at least one designated staff member attending these trainings and will be responsible for implementing the activities they are trained to do.

5.2 RECOMMENDATIONS FOR FUTURE RESEARCH

We made baseline costs and varying costs for the compliance of the new permit. However, the costs related to TMDL, as mentioned in background chapter, varies in a large extent. A future study group may consider studying the varying cost of TMDL.

The cost of implementing the MS4 permit is very high. The funding mechanisms could be studied. One potential good way to fund it is implementing a stormwater utility. Another future project could be finding the best way to charge for a stormwater utility. It could include billing by impervious area, total area, or even a flat resident rate.

A social marketing research on the most impactful public education message could be very helpful in the outcome of public education. Public Education minimum control measure didn't specify the detailed education message but it would be beneficial to use the message that is most likely to facilitate behavioral changes of the public. The potential method could be using surveys on DPW workers who clean catch basin about the difference they observe before and several months after implementing the education message. Specifically, the DPW could set up signage or send out brochures with different educational messages at different randomly selected locations. It is expected that the most impactful message will result in a larger percentage of reduction, in terms of the amount of illicit discharge/trash in catch basin areas.

6.0 CONCLUSION

Stormwater pollution is a major issue that has just begun to be regulated within the past 20 years. With the issue of the Municipal Separate Storm Sewer System (MS4) permit, towns now have an added cost to their budgets. For our project we analyzed the cost of implementing the upcoming Massachusetts MS4 permit, which is expected to come out in 2014.

In the Findings chapter, case studies on four subject towns were addressed. The case studies were built from interviews with experienced professionals and research through data bases and town websites. After the case studies were set up, we were able to construct cost sheets for each municipality. The cost sheet is constructed from our interviews and research from their NPDES Phase II MS4 permit annual report. The cost sheet is a layout of what the towns are doing now to comply with the MS4 permit and those costs associated with stormwater management. The case studies that were built include information on each town and important cost information that we learned from our interviews with the town officials or consultants.

The baseline cost and varying cost of implementing the MS4 permit are two of the most important parts of our analysis of our data present on the cost sheets. We broke down the costs that will be needed for each town regardless of size. We called this the baseline cost, which incorporated costs such as passing bylaws which did not vary greatly from town to town. We decided to include a range for each cost due to there being a low estimation and a high estimation for each cost factor.

The varying costs ranged widely and fluctuated between the towns. Examples of varying costs include mapping, catch basin and outfall inspections, and outfall sampling. Each of these requirements varies depending on factors such as number of catch basins or outfalls, percent impervious surface area, or total area of the town.

To pay for these programs, towns have looked towards sharing costs. Sharing resource scan help lower the cost for each municipality involved. One example we looked into for our project was the Central Massachusetts Regional Stormwater Coalition, which works with 30 central Massachusetts towns to share resources and helps towns comply with the MS4 permit.

The MS4 permit gives towns leeway in how they comply with the requirements. One way is to hire consultants to complete stormwater management tasks. As discussed in our findings chapter, consultants were more expensive than doing the work in house, but it gave the towns the opportunity to work with professionals that have specialized knowledge about and experience with stormwater management.

This report assumes that the municipalities will seek the most cost efficient way for minimally complying with the MS4 permit according to the requirements of New Hampshire 2013 draft MS4 permit. The permit itself will be very difficult for towns to comply with due to lack of resources, time and stormwater specific technical expertise. It is our hope that after reading our report, towns will have a better understanding of the upcoming Massachusetts permit and its associated costs. The costs and methods presented should help towns realize and perhaps, prepare for the financial implications of the new anticipated MS4 permit. The task will be difficult but with correct awareness and actions, towns will be able to be in compliance and more importantly, work to preserve our environment.

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APPENDIX A. SAMPLE INTERVIEW QUESTIONS

PREAMBLE

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to learn more about the costs of implementing the MS4 permits in Massachusetts. With this information from our interview, you will help us further our cost analysis and learn more about each municipality. Your participation in this survey is completely voluntary and you may withdraw at any time. If you so wish, we can keep your answers anonymous with no identifying information will appear on our project reports or publications. This is a collaborative project between the DEP and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the interview.

INTERVIEW QUESTIONS TO AUBURN – MARCH 25TH

1. How did you approach establishing the stormwater utility?

2. What was your major issue with the stormwater utility?

3. How did you work out your cost breakdown for your methodology?

4. Was your proposed utility in house or would you hire a consultant?

5. What are your thoughts on your proposed cost analysis?

6. What were the major difficulties when you did the cost analysis? Specifically, for materials and labors?

7. Would it be possible to re-visit/interview with you should we have more questions?

INTERVIEW QUESTIONS TO UPTON – APRIL 1ST

1. What tasks does Verdant Water do for Upton?

2. Could you provide us with the annual cost report? Or budget report?

3. How much do you spend on public education?

a. Cost to develop and distribute brochures to residents/businesses?

b. Cost of signage?

c. Cost of household hazardous waste collection?

d. Develop and distribute school curricula.

4. Cost of public involvement

a. Public meeting on stormwater management plan

b. Sample Pratt pond weekly

c. Beach cleanup and signs

5. Cost of IDDE?

a. What are included in the stormwater system map and how much does it cost to complete it?

b. How long does it take to create a list of illicit discharges and how much does it cost?

c. How much does it cost to remove illicit discharges (in the past it was zero).

d. How long does it take to adopt new bylaws?

e. Develop employee training programs to identify illicit discharges.

f. Do you know how much it would cost to do wet/dry weather sampling?

6. Construction site

a. Develop procedures to inform the public the upcoming projects and how much does it cost?

b. How much does it cost to develop and implement site plan review processes?

c. Implement erosion and sediment control ordinances

d. How much does it cost to develop construction inspection program?

e. How much does it cost to implement construction inspection program including fines for violations?

7. Post Construction

a. How much do you spend review existing non-structural BMPs?

b. How much do you spend review existing structural BMPs?

c. How much does it cost to catalog all new structural BMPs?

d. Develop inspection program for newly installed BMPs?

e. How much does it cost to conduct inspection of BMPs within the first year of operation?

8. Pollution prevention/ Good housekeeping

a. How much does it cost to inspect town own sand/salt storage areas?

b. Do we only have one person dedicated to catch basin cleaning and street sweeping? And their salary?

c. Cost to develop maintenance schedule?

d. Cost for development of employment training program?

e. What BMP's does Upton use to manage stormwater? What is the cost of implementation and maintenance?

INTERVIEW QUESTIONS TO OXFORD – APRIL 10TH

1. Do you have a contractor for stormwater? What do they do for you?

2. Could you provide us with the annual cost report? Or budget report?

3. How much do you spend on public education?

a. Cost to develop the stormwater section on the town website?

b. Cost to develop the stormwater broadcast section on local TV (if you did it)?

c. Cost of distribute brochures and factsheets to residents/businesses?

d. Cost of developing stormwater management video (if it has been completed)?

4. Cost of public involvement

   a. Cost of cleaning river, stream, and pond?

   b. Mark storm drains with buttons and stencils?

5. Cost of IDDE?

   a. Cost to develop town storm drain mapping?

   b. Cost to put illicit discharge prohibition ordinance in place?

   c. Have you developed an IDDE plan and implementing activities? If so, what's the cost?

   d. Cost to take stormwater calls?

6. Construction site

   a. Develop erosion control regulation?

   b. Conduct inspections for erosion controls?

7. Post Construction

   a. How much do you spend develop BMP regulation?

   b. How much do you spend develop and implement the inspection program?

8. Pollution prevention/ Good housekeeping

   a. How much does it cost to clean catch basins?

   b. How much does it cost to sweep streets?

   c. Do you only have one person dedicated to catch basin cleaning and street sweeping? And their salary?

   d. Cost to develop maintenance schedule?

   e. Cost for evaluate municipal facilities for potential stormwater impacts?

   f. Cost for ensuring proper waste disposal in town for hazardous and special waste?

   g. Cost to conduct town employee stormwater training?

INTERVIEW QUESTIONS TO WESTBOROUGH – APRIL 17TH

1. Do you have a contractor for stormwater management? What do they do for you?

2. Could you provide us with the annual cost report? Or budget report?

3. How much do you spend on public education?

    a. Cost to mail educational flyer with survey to homeowners? Once?

    b. Cost to teach stormwater lessons to students?

    c. Cost to mail educational flyer with survey to businesses?

    d. Cost to hold media campaign?

    e. Cost to air stormwater video on local station?

4. Cost of public involvement

    a. Cost of circulating stormwater traveling display?

    b. Cost of holding stormwater summits?

    c. Cost of catch basin stenciling?

5. Cost of IDDE?

    a. Cost to develop town storm drain mapping?

    b. Cost to develop bylaw for discharging into storm sewer systems?

    c. Cost to develop enforcement procedures for above?

    d. Cost of identifying illicit discharges?

    e. Cost of developing and implementing plan to detect and address illicit discharges?

    f. Cost of IDDE inspection?

    g. Cost of program to evaluate and report on condition after illicit material removed?

6. Construction site

    a. Cost of developing erosion control bylaw?

b. Cost of implementing pre construction review of stormwater control plan for proposed construction sites?

c. Conduct inspections for construction sites?

d. Cost of reports for non-compliance?

7. Post Construction

a. How much do you spend develop BMP regulation?

b. How much do you spend develop and implement the inspection program?

c. Cost of develop operation and maintenance procedures for structural BMPs?

8. Pollution prevention/ Good housekeeping

a. How much does it cost to clean catch basins? Cost of enhancement?

b. How much does it cost to sweep streets? Cost of enhancement?

c. Do you only have one person dedicated to catch basin cleaning and street sweeping? And their salary?

d. Cost of employee training?

e. Cost of structural BMP inspection and maintenance program?

INTERVIEW QUESTIONS TO WEBSTER – APRIL 22ND

1. What are we going to sample? So that we know which kit to use.

2. What tasks do Tighe & Bond do for your town?

3. Could you provide us with the annual cost report? Or budget report relevant to stormwater?

4. How do you enforce routine checks on construction site/post-construction and what is the cost associated with it?

5. How much did you spend on public education?

a. How much does it cost to create and distribute educational flyers?

b. Cost of creating a stormwater related page on your town website?

c. Cost of the newspaper press releases

d. Cost of creating an ad on local cable TV channels?

e. How much did you expect the hazardous waste collection day cost? (you mentioned not done due to budget cut in the stormwater report)

f. How much time do you think the stormwater management committee meets during the past year? How many committee members? Estimated labor cost?

6. Do you have a projected cost for the catch basin stenciling?

7. What does the Webster Lake Association test for?

8. How much did you spend on mapping?

   a. What were you mapping?

9. Number of outfalls/catch basins?

10. How much do you expect future projects to cost under you Capital Planning budget?

11. How much did it cost to do the drain line work on Frederick Street? (cost per ft)

12. How much money did you spend on the web based GIS system?

13. How much did the site plan reviews cost?

14. Do you charge a fee to businesses to look at their stormwater plans?

15. How many employees do you have to oversee regulations and ordinances?

16. How much money do you spend for wages and salaries for stormwater projects?

17. How much money do you spend creating BMPs?

18. How much money do you spend maintaining BMPs?

19. How much do you spend on street cleaning?

20. How much do you spend on catch basin cleaning?

21. How much do you spend on purchasing salt?

22. How much do you spend on salt storage?

23. How much do you spend on salt distributing?

24. How much do you spend on outfall cleaning and monitoring?

25. How much money do you spend on employee training?

26. How much do you plan on spending on your SWPPP?

APPENDIX B. SAMPLE COST COMPONENTS SPREADSHEET

Sample Cost Components Spreadsheet

Public Education and Outreach	Materials			Labor			Total cost
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Pamphlets/Brochures to residents							
Research Communication Channels							
Develop appropriate material (i.e. pamphlets)							
Poster							
Video							
Newspapers							
Signs							
Broadcasting							
Develop collection program for hazardous waste							
Develop school curricula and distribute to schools							
educational training materials							
Media Campaign							
website							

Public Involvement	Materials			Labor			Total cost
	Total Materials	Multiplier	Costs per	Wage	Hours	Total labor	Total cost

and Participation	Cost		unit				
Mark storm drains							
Public Involvement and Identify opportunities for Public Involvement							
Develop methods to gauge outreach effectiveness							
native tree and shrub planting							
classroom education program							
prepare press releases							
Develop and implement composting program							
Form citizen watch groups to identify polluters							
Educational Outreach Materials							
Roadside Cleanup day							
Catch Basin Stenciling							
Poster Contest for students							
Stormwater Management Committee							
Public meetings							
Stormwater brochure and town meeting							

IDDE Program	Materials			Labor			Total cost
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Outfall Mapping							
Catch Basin Mapping							
Map Structural BMPs							
Flyover mapping							
Illicit discharge prohibition ordinance/bylaw*							

Develop IDDE program							
Outfall Monitoring							
Develop employee training program to identify discharges							
Identify Illicit discharges							
Rank catchment areas							
Outfall sampling dry							
Outfall sampling wet							
Develop stormwater management program web based GIS system							
Outfall research and planning							
Outfall inspecting							
Delineate Catchment areas							

Construction and Post-Construction Site Stormwater Runoff Control	Materials			Labor			Total cost
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Develop Erosion Control Regulations*							
Site inspecting and enforcement							
Site plan review							
Annual report on impervious area							
Review existing design standards with respect to incorporating Low Impact Development							
Ranking of BMP effectiveness							
Develop construction inspection program and inspect							

Permit review							

Post Construction Stormwater Management	Materials			Labor			Total cost
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Develop BMP Regulation*							
Develop and Implementation Inspection Program							
review existing BMPs							
Develop inspection program of installed BMPs							
Zoning							
Urban Forestry							
Eliminate curbs and gutters							
Conduct inspections of BMPs within 1st year of operation							
Develop operation and maintenance procedures for structural BMPs							

Good House Keeping and Pollution Prevention	Materials			Labor			Total cost
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Clean Catch Basins							
Sweep Streets							
Road salt/sand management							
Develop written procedures for operation and							

maintenance for municipal activities							
Municipal SWPPP							
Infrastructure repair and rehab plan							
Develop and implement maintenance schedules of BMPs							
Employee training program							
Review and update town's recycling program							
Management program for fertilizer and pesticide application							
Maintenance and repair programs for municipal vehicles							
Annual Reporting							
NOI and SWMP finalization							

APPENDIX C. DETAILED COST SHEET FOR TOWNS' CURRENT EXPENDITURE

For all the cost sheets, we did not include inspection costs under IDDE Program except Webster, and they are listed in terms of six different control measures for each town. The asterisks denotation is explained below:

* = one-time cost

** = does not include consulting cost

Most cost numbers are rounded to the nearest $1000. However, if the estimation is under a smaller scale, they could be estimated to the nearest $100 or $10.

DETAILED UPTON COST SHEET

Public education and Outreach	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Pamphlets/Brochures to residents	500						500
Signs	2,450	10	245			1,000	3,450
website	1,200					1,000	2,200

Public Involvement and Participation	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost

Stormwater Management Committee	4,000					6,000	10,00 0
Stormwater presentation at town meeting	2,000					1,000	3,000
Stormwater brochure and town meeting	1,000					500	1,500

IDDE Program	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Outfall Mapping	2,000					500	2,500
Catch Basin Mapping	4,000					1,000	5,000
Illicit discharge prohibition ordinance/bylaw*	6,000					2,000	8,000
Develop employee training program to identify discharges	1,000					1,000	2,000

Construction Site Stormwater Runoff Control	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Develop Erosion Control Regulations*	2,000					1,000	3,000
Conduct Inspections for Erosion Controls						2,000	2,000
Develop and implementation site plan review process for sites						2,000	2,000
Develop						10,00	10,00

construction inspection program and inspect						0	0

Post Construction Stormwater Management	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Develop BMP Regulation*	2,000					1,000	3,000
review existing BMPs							5,000
Develop inspection program of installed BMPs							

Good House Keeping and Pollution Prevention	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Clean Catch Basins	5,000					500	5,500
Sweep Streets	5,000					500	5,500
Road salt/sand management						1,500	1,500
Employee training program	2,500					7,000	9,500
Municipal SWPPP						1,000	1,000

DETAILED OXFORD COST SHEET

Public education and Outreach	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Signs	0	0	0			5,000	5,000

Public Involvement and Participation	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
river, stream and pond cleanups						10,000	10,000

IDDE Program	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Outfall Mapping	12,500					7,000	19,500
Catch Basin Mapping	12,500					7,000	19,500
Illicit discharge prohibition ordinance/bylaw*	6,000					2,000	8,000
Develop employee training program to identify discharges	1,000					1,000	2,000
Identify Illicit discharges						7,000	7,000
Dry weather inspections and sampling per year**			250*(number of				190X 289/5

			wet weather **				
Wet weather inspections and sampling per year**			500*(number of dry weather inspections)**				190X 289/5

Construction Site Stormwater Runoff Control	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Develop Erosion Control Regulations*	2,000					1,000	3,000
Conduct Inspections for Erosion Controls						7,000	7,000
Develop and implementation site plan review process for sites						2,000	2,000
Develop construction inspection program and inspect						10,000	10,000

Post Construction Stormwater Management	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost

Develop BMP Regulation*	2,000					5,000	7,000
review existing BMPs							5,000
Develop inspection program of installed BMPs							

Good House Keeping and Pollution Prevention	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Clean Catch Basins	5,000					25,000	30,000
Sweep Streets	20,000					27,500	47,500

DETAILED WESTBOROUGH COST SHEET

Public education and Outreach	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
General public education material	2,500						2,500

Public Involvement and Participation	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost

IDDE Program	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Outfall Mapping						50,000	50,000
Catch Basin Mapping						50,000	50,000
Dry weather inspections per year **							190*(number of wet weather inspections)
Wet weather inspections per year **							190*(number of dry weather

							inspections)

Construction Site Stormwater Runoff Control	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
General Inspection						10,000	10,000

Post Construction Stormwater Management	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost

Good House Keeping and Pollution Prevention	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Clean Catch Basins	25,000						25,000
Sweep Streets						30,000	30,000

General Staff							220,000

DETAILED WEBSTER COST SHEET

Public Education and Outreach	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Research Communication Channels	2,000						2,000
Develop appropriate material (i.e. pamphlets)	2,400						2,400

Public Involvement and Participation	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Public Involvement and Identify opportunities for Public Involvement	800						800
Develop methods to gauge outreach effectiveness	1,500						1,500
Public meetings	3,600					0	3,600

IDDE Program	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Outfall Mapping	45,000					0	45,000
Catch Basin Mapping	45,000					0	45,000
Map Structural	12,000						12,00

BMPs							0
Flyover mapping	15,000						15,000
Illicit discharge prohibition ordinance/bylaw*	11,000						11,000
Develop IDDE program	33,000						33,000
Outfall Monitoring	12,000						12,000
Develop employee training program to identify discharges	10,000					0	10,000
Identify Illicit discharges	8,000					0	8,000
Rank catchment areas	8,500						8,500
Outfall sampling dry	7,500						7,500
Outfall sampling wet	7,500						7,500
Develop stormwater management program web based GIS system	22,000						22,000
Outfall research and planning	37,000						37,000
Outfall inspecting	12,500						12,500
Delineate Catchment areas	23,000						23,000

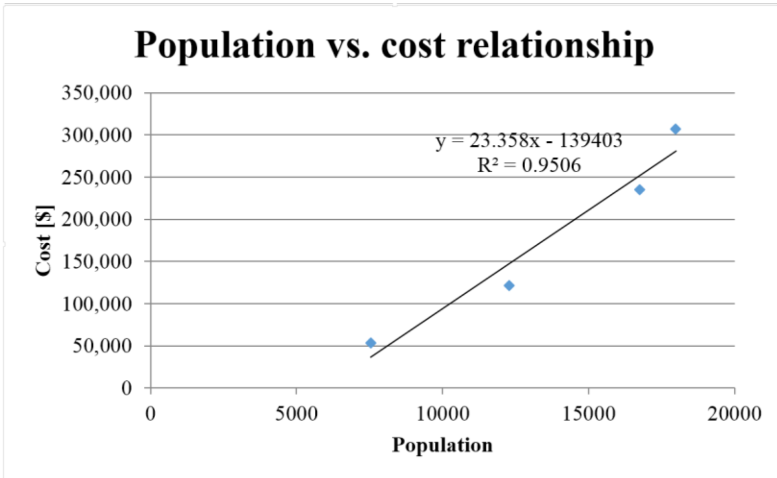
Construction and Post-Construction Site Stormwater Runoff Control	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Develop Erosion Control	10,000						10,000

Regulations*							
Site inspecting and enforcement	6,000					0	6,000
Site plan review	4,000						4,000
Annual report on impervious area	12,000						12,000
Review existing design standards with respect to incorporating Low Impact Development	4,000					0	4,000
Ranking of BMP effectiveness	8,000						8,000
Develop construction inspection program and inspect	10,000					0	10,000
Permit review	3,000						3,000

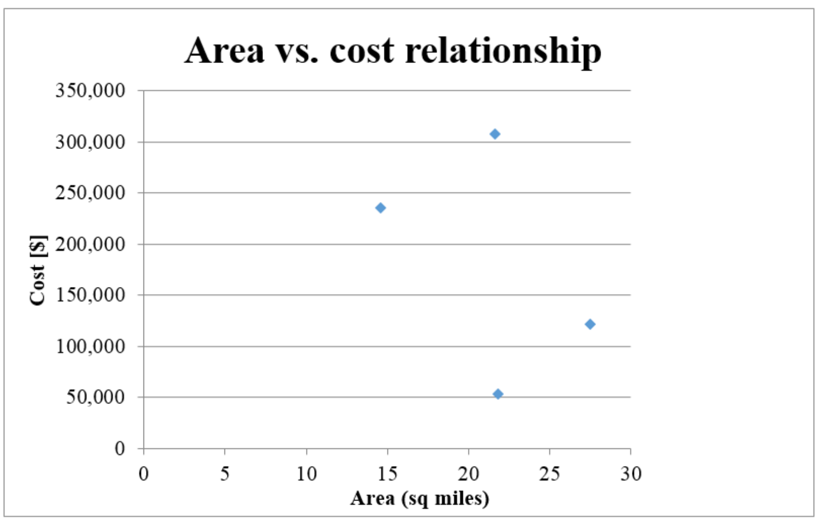
Good House Keeping and Pollution Prevention	Materials [$]			Labor [$]			Total cost [$]
	Total Materials Cost	Multiplier	Costs per unit	Wage	Hours	Total labor	Total cost
Clean Catch Basins	20,000						20,000
Sweep Streets	12,000						12,000
Develop written procedures for operation and maintenance for municipal activities	7,000						7,000
Municipal SWPPP	7,000						7,000
Infrastructure repair and rehab plan	8,000						8,000
Annual Reporting	6,000						6,000
NOI and SWMP finalization	3,000					0	3,000

APPENDIX D. COST DRIVER CHARTS

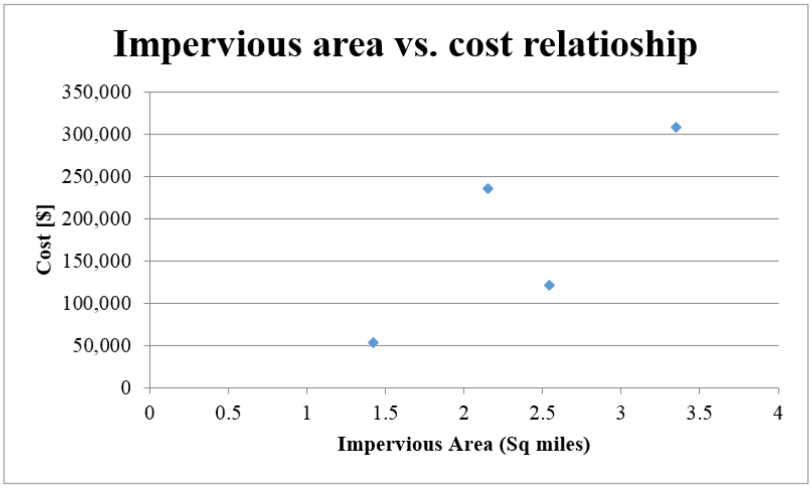
Population vs. cost



Area vs. cost



Impervious area vs. cost


Impervious area vs. cost relatioship
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Cost [$]
0
0.5
1
1.5
2
2.5
3
3.5
4
Impervious Area (Sq miles)