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Stormwater Management Educational Materials for Central Massachusetts Municipalities

Worcester Polytechnic Institute
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Stormwater Management Educational Materials for Central Massachusetts Municipalities

An Interactive Qualifying Project Report
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Central Massachusetts Regional Stormwater Coalition (CMRSWC)

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Abstract

Stormwater runoff is the leading cause of water pollution in the United States. To help with this issue, the *United States Environmental Protection Agency* issued an updated *Municipal Separate Storm Sewer System* permit for Massachusetts in April 2016, which includes more stringent requirements. Municipalities in Massachusetts anticipate struggling to comply with the permit given their limited resources. The goal of this project, in collaboration with the *Massachusetts Department of Environmental Protectio*n and the *Central Massachusetts Regional Stormwater Coalition*, was to develop educational materials to help municipal officials comply with the permit. From our interviews and survey, we created a compliance guideline and provided suggestions for municipalities on preparing for the permit.

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Executive Summary

As rain falls on impervious surfaces, such as roads or parking lots, it washes away to the nearest storm drain, picking up pollutants along the way, and is discharged untreated to a nearby waterbody. This is known as stormwater runoff, and is one of the major causes of water pollution in the United States.

Stormwater runoff often flows into *Municipal Separate Storm Sewer Systems (MS4s)*, which are a conveyance or system of conveyances that collect and redirect stormwater into nearby waterbodies. In 1990, the *United States Environmental Protection Agency (USEPA)* established the MS4 permit, pursuant to their Federal Clean Water Act power, to improve water quality by reducing pollutant discharge carried by stormwater runoff. In 2003, the USEPA issued a Small MS4 General permit for MS4 operations in Massachusetts and New Hampshire municipalities.

On April 4th, 2016, the USEPA signed the 2016 Massachusetts Small MS4 General permit, which will become effective and replace the 2003 permit on July 1, 2017. The municipalities in central Massachusetts are seeking help to comply with the additional requirements in the 2016 permit. As the liaison between the USEPA and central Massachusetts municipalities, the *Massachusetts Department of Environmental Protection (MassDEP)* works with many municipalities and nonprofit watershed coalitions in order to provide assistance. However, it is difficult for the MassDEP to properly address the issues of MS4 permit compliance given their limited labor force and funding (A. Briggs. personal communication, April 11, 2016).

The goal of our project, in collaboration with the MassDEP, the *Central Massachusetts Regional Stormwater Coalition (CMRSWC)*, and the town of Holden, Massachusetts, was to develop educational materials for local municipalities on how to prepare for the 2016 MS4 permit. To meet this goal, we completed the following five objectives:

- Objective 1: Identify changes between the 2003 and 2016 MS4 permit;
- Objective 2: Identify areas of the permit that municipalities in other states, including Connecticut, New Hampshire, Minnesota, and Rhode Island have struggled with, and areas that central Massachusetts municipalities anticipate struggling with;
- Objective 3: Identify how other states have educated municipalities about MS4 permit requirements and determine most appropriate educational method for central Massachusetts municipalities;
- Objective 4: Develop educational materials using findings from objectives 2 and 3; and
- Objective 5: Create and document the process of creating a video for the Town of Holden residents about stormwater runoff to help comply with the "Public Education and Outreach" minimum control measure.

Methodology

To gain a comprehensive understanding of the permit, we read through both the 2003 and 2016 Massachusetts Small MS4 General permits. We created a table of changes between the permits to help us understand which sections municipalities will need the most help with. From here, we carried out multiple semi-structured interviews with stormwater experts across various states to better understand the challenges that municipalities face when complying with General MS4 permits. We chose to use semi-structured interviews, as this gave us the opportunity to ask respondents the same set of questions to compare their responses, while also giving us a chance to deviate from the questions to gain further insight into particular issues or techniques that came up in discussion. We interviewed the directors of various *Nonpoint Education for Municipal Officials (NEMO)* programs, as well as members of various watershed coalitions and the stormwater manager of the *New Hampshire Department of Environmental Services (NHDES)*.

In addition to the interviews, we consulted with Andrea Briggs and Frederick Civian, our sponsors at the MassDEP; and Newton Tedder, a USEPA employee who drafted the 2016 MS4 permit, to gain further insight into areas of the permit they anticipate municipalities will struggle

with. We also developed a survey for the CMRSWC Steering Committee members, who are responsible for stormwater management in various towns in central Massachusetts. The survey was designed to get insight into what areas of the permit municipal officials feel they need the most assistance with, and how we should present the materials we created.

Findings

From our research, we determined that **the most difficult sections of the permit to comply with are *Geographical Information System (GIS)* mapping, *Illicit Discharge Detection and Elimination (IDDE)*, and water quality impaired waters**. In asking our survey respondents which minimum control measure they were most concerned about, nine (9) out of 12 respondents indicated they were "most concerned" about IDDE, more than twice that of any of the other minimum control measures (see Figure 1 below).

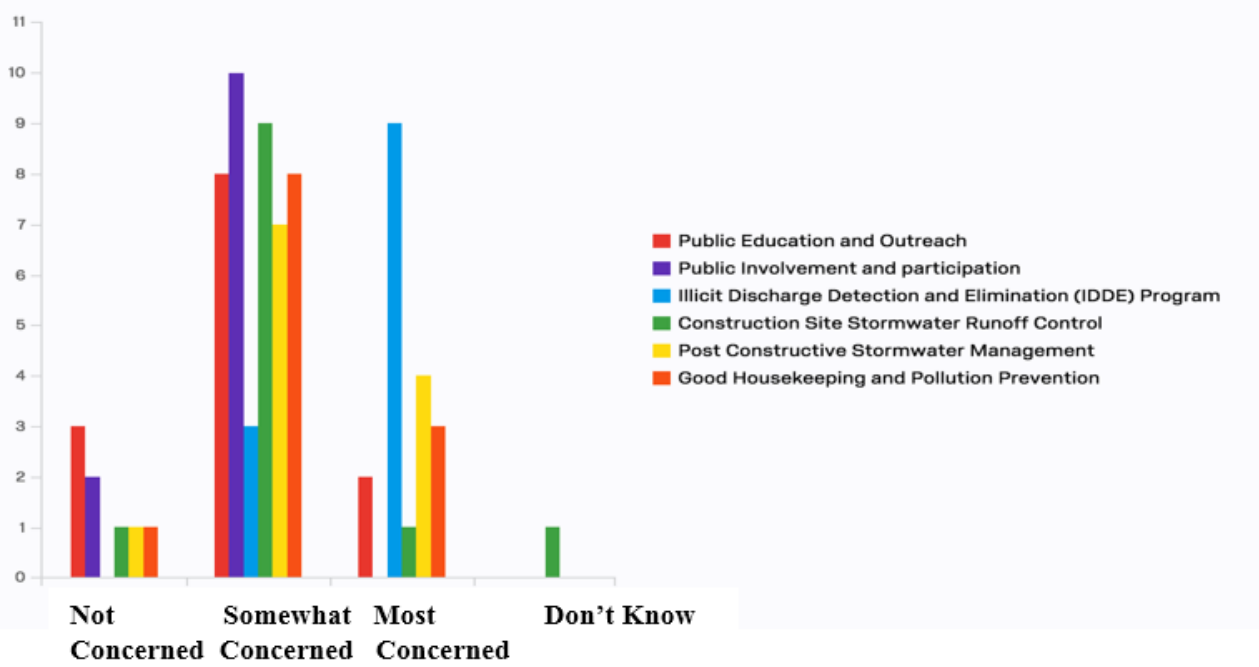

Figure 1. Survey Results for Question 6 in "Survey for the CMRSWC steering committee"

In our interview with John Billota, director of the Northland NEMO program (in Minnesota and Wisconsin), he mentioned that after an updated MS4 permit was issued in Minnesota in 2014,

the Northland NEMO program focused their efforts towards the IDDE and *Total Maximum Daily Loads (TMDLs*; part of water quality impaired waters) sections of the permit. Jeffery Andrews, from the NHDES, explained that small towns will likely not have the technical expertise required to meet the GIS and IDDE requirements, and that he expects towns to have trouble with the water quality limited waters requirements (personal communication, May 18, 2016). Both interviewees' opinions support the result shown in the survey.

The biggest obstacle for towns will be the limited resources they have to comply with the permit. As illustrated by Figure 2, below, our survey results indicate that the three biggest issues that municipal officials anticipate having when complying with the permit are "Too few personnel," "Financial reasons," and "Necessary equipment". Out of 13 respondents, 12 indicated their municipality does not have enough personnel to carry out necessary tasks; nine (9) pointed to financial reasons as the biggest obstacle; and seven (7) selected "Availability of necessary equipment" as a concern.

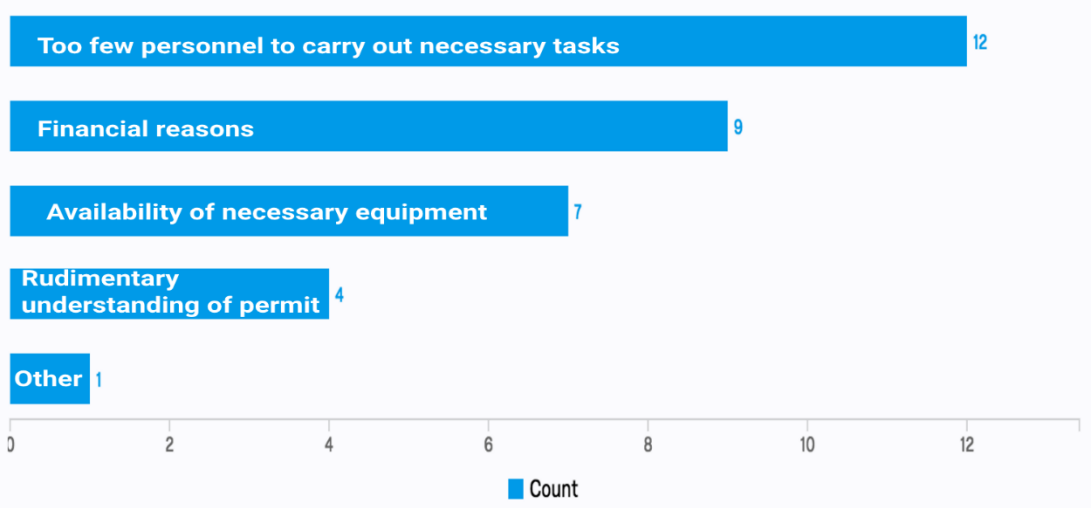

Figure 2: Obstacles with the 2016 MS4 permit compliance

Through our interviews with 11 stormwater experts and from the results of our 13 survey responses, we determined **the most effective delivery method for educating municipal officials is through in-person workshops**. According to Mr. Billota, adults like to "get their hands dirty" when learning (personal communication, May 26, 2016). One method he found to work well is to take municipal officials on bus tours, or out on boats to give workshops, as it is easier to show the impact that stormwater runoff can have. Workshops allow for open forum discussions among members. In our survey, we asked respondents "What delivery method would you find most effective for learning some of the nuances of the MS4 permit?" six (6) of the 11 respondents (55%) claimed that in-person workshops would be most effective.

From our research on educational methods for MS4 permit compliance, we found that **there are many existing educational materials available for towns to help them comply with the *Public Education and Outreach* minimum control measure**. The Connecticut NEMO, Rhode Island NEMO, Northland NEMO, the *Massachusetts Watershed Coalition (MWC)*, and the USEPA all provide different types of educational materials through various mediums, such as phone apps, websites and videos (see Appendix G for links to existing resources).

Timelines, template language, and checklists are the most applicable educational materials for central Massachusetts municipalities. In the survey, we asked the Coalition members what educational materials they want to have. Out of 13 respondents, six (6) chose template language and two (2) suggested a list of requirements. Our interviews with the directors of three (3) NEMO programs also confirmed our finding from the survey. In addition to template language and checklists, Mr. Andrews pointed us to timelines of the requirements in the permit because he found that timelines are helpful tools for the New Hampshire municipalities (personal communication, May 18, 2016).

By analyzing all of our findings, we found what central Massachusetts municipal officials want and what methods stormwater experts found to be effective. We created a document called "MS4 Compliance Guideline", which contains step-by-step instructions, checklists, and timelines (see Appendix E for "MS4 Compliance Guideline").

Recommendations

As discussed above, one of the biggest issues for central Massachusetts municipalities is a lack of resources available to them. For this reason, **we recommend towns join or create a coalition or other combined body to manage the MS4 permit requirements**. This not only gives town officials a forum to discuss issues they are facing, but allows them to save money by sharing expensive equipment necessary to meet some permit requirements.

We also recommend that municipalities start developing and implementing a plan to comply with the permit, as the deadlines are quickly approaching. To aid in this process, we recommend towns attend MS4 workshops hosted by the MassDEP and the USEPA.

Given that coalition members are most concerned about GIS mapping, IDDE, and water quality impaired waters according to our research, **we recommend that the coalition hold workshops on these topics to best assist municipalities.** The Coalition should also look into existing workshops and educational materials developed by other organizations such as the NEMO programs, the MassDEP, the USEPA, and the MWC. We further recommend that the Coalition make the MS4 Compliance Guideline available to municipalities to help them comply with the permit.

Most of the comments from the municipalities on the 2016 MS4 permit are about the ambiguous terms in the permit. **We recommend that the USEPA include more examples for**

ambiguous language and provide additional links to useful resources on their website to guide municipal officials to what they are looking for.

To address the serious impact of stormwater runoff, the USEPA issued an updated 2016 MS4 permit with more stringent requirements for Massachusetts. Central Massachusetts municipalities anticipate struggling to meet the MS4 permit requirements due to their limited resources. The MassDEP and the CMRSWC tasked us to assist central Massachusetts municipal officials to comply with the 2016 MS4 permit. We interviewed stormwater experts and surveyed the CMRSWC members. With findings from our interviews and survey, we developed a MS4 Compliance Guideline and an educational video for the town of Holden, and provided central Massachusetts municipalities, the CMRSWC, and the USEPA with our recommendations on MS4 permit compliance. We believe the MS4 Compliance Guideline we created will allow municipalities to better comply with the 2016 MS4 permit, and in turn best use their available resources to improve the community's water quality.

Authorship

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Chapter 1: Introduction	All	All
Chapter 2: Literature Review and Background	Zixin Luo (Introduction)	Nicholas Rowles, Zixin Luo
2.1 Causes and impacts of water pollution	Zixin Luo	All
2.2 Stormwater runoff	Geneva Cabral	All
2.3 Methods to address water pollution	Geneva Cabral, Nicholas Rowles	All
2.4 Methods to educate municipal officials about MS4 permit	Zixin Luo	Zixin Luo, Nicholas Rowles
2.5 Research gap and summary	Zixin Luo, Nicholas Rowles	Zixin Luo, Nicholas Rowles
Chapter 3: Methodology	Zixin Luo (Introduction)	Nicholas Rowles
Objective 1: Identify changes between 2003 and 2016 MS4 permit	Zixin Luo	All
Objective 2: Identify areas of the permit that municipalities in other states, including Connecticut, New Hampshire, Minnesota, and Rhode Island have struggled with, and areas that central Massachusetts municipalities anticipate struggling with	Zixin Luo	Zixin Luo, Nicholas Rowles
Objective 3: Identify how other states have educated municipalities about MS4 permit requirements and determine most appropriate educational methods for central Massachusetts municipalities	Geneva Cabral	All
Objective 4: Develop educational materials using findings from Objective 2 and 3	Nicholas Rowles	Nicholas Rowles, Zixin Luo
Objective 5: Create and document the process of creating a video for the town of Holden residents about stormwater runoff to help comply with the "Public Education and Outreach" minimum control measure	Geneva Cabral	All
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5.4 Recommendations for the USEPA	Zixin Luo	Zixin Luo, Nicholas Rowles
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Appendix B: Sample interview protocol	Zixin Luo	Nicholas Rowles, Zixin Luo
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List of Acronyms

CDC	Centers for Disease Control and Prevention
CMRSWC	Central Massachusetts Regional Stormwater Coalition
CSO	Combined Sewer Overflow
CT NEMO	Connecticut Nonpoint Education for Municipal Officials
CWA	Clean Water Act
DPW	Department of Public Work
FWPCA	Federal Water Pollution Control Act
GIS	Geographic Information System
IDDE	Illicit Discharge Detection and Elimination
LID	Low Impact Development
MassDEP	Massachusetts Department of Environmental Protection
MS4	Municipal Separate Stormwater Sewer System
MWC	Massachusetts Watershed Coalition
NEMO	Nonpoint Education for Municipal Officials
NLA	National Lakes Assessment
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NROC	Natural Resources Outreach Coalition
SEP	Stormwater Educational Program
SSO	Sanitary Sewer Overflow
SWMP	Stormwater Management Program
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
WPI	Worcester Polytechnic Institute
WROC	Water Resource Outreach Center

1.0 Introduction

Stormwater runoff is one of the primary causes of water pollution in the United States (USEPA, 2012a). Stormwater runoff occurs due to rainstorms and snowmelt, where the stormwater flows over impervious surfaces directly into surface water bodies without filtration or treatment. The stormwater runoff carries many pollutants, such as oil, sediments, leaves, toxic chemicals, and other hydrocarbons. The pollutants that get into rivers, creeks, lakes, and bays affect human and aquatic life (USEPA, 2012a).

Although it is imperative to keep surface water clean, many municipalities in the central Massachusetts area do not have sufficient resources available to properly manage stormwater runoff (CMRSWC, 2016e). The municipalities usually own or operate *Municipal Separate Storm Sewer Systems (MS4s)*, which is a system to collect and convey stormwater runoff (USEPA, 2003).

The *United States Environmental Protection Agency (USEPA)* established the first MS4 permit in 1990, which focused on regulating MS4s with the goal of reducing stormwater pollution. In 2003, the USEPA released the first permit for Small MS4s in Massachusetts. This permit set forth requirements that municipalities had to comply with (USEPA, 2003). On April 4th, 2016, the USEPA released an updated permit for Small MS4s in Massachusetts. The updated 2016 MS4 Permit includes more stringent requirements that must be met by municipalities in order to discharge from their MS4s (USEPA, 2016c). Most central Massachusetts municipalities do not have the personnel and budget to research and determine the best ways to comply with the new requirements.

To address the issues of stormwater runoff and MS4 permit compliance, current research focuses on stormwater treatment, the evaluation of stormwater runoff, and education on stormwater management. Some researchers have focused on removing “dissolved nitrogen,

phosphorus and carbon from stormwater" (Henderson, Greenway, & Phillips, 2007, p.183). Other researchers have focused on the evaluation and measurement of the amount of stormwater runoff (Vinciūnas, Rimeika, & Janeliauskienė, 2011).

Besides research on treating and measuring stormwater runoff, there is also considerable research on stormwater education. Of note is the *Nonpoint Education for Municipal Officials (NEMO)* program, which provides town officials with education and assistance on land and natural resource management (CT NEMO Program, 2016; Northeast States & Caribbean Islands Regional Water Center, 2016). For instance, NEMO has helped local New Hampshire communities better comply with the New Hampshire MS4 permit (University of New Hampshire, 2015).

In Massachusetts, research has been done surrounding the updated MS4 permit and the impact it will have on stormwater management in local communities (Barat, Chin, & Feraco, 2013; Bond, Racine, & Yang, 2013; Correia, Giroux, & Peterson, 2014; Deng, Houghton, Li, & Weiler 2014). However, there has been no research done that looks into how these communities should best use their available resources and what assistance the municipalities are looking for to adapt to the changes in the 2016 MS4 permit.

The goal of our project, in collaboration with the *Massachusetts Department of Environmental Protection (MassDEP),* the *Central Massachusetts Regional Stormwater Coalition (CMRSWC)*, and the town of Holden, was to develop educational materials for municipal officials on how to comply with the 2016 MS4 permit. To complete this project, we first identified the key changes in the 2016 MS4 permit. Next, we evaluated what other states have done to educate municipal officials about MS4 requirements by conducting interviews. We also determined the areas in the 2016 MS4 permit that municipal officials are most concerned about based on the results of our survey. Once we completed these objectives, we analyzed the most applicable methods and

educational materials for central Massachusetts municipal officials. Based on this analysis, we developed a MS4 Compliance Guideline, which contains checklists, step-by-step instruction, and timelines for requirements in the 2016 MS4 permit, and received feedbacks from our target audiences.

We discuss stormwater runoff, MS4 permits, and organizations such as NEMO in chapter 2. Next, in chapters 3, 4, and 5, we describe our methodology for the project, the findings from our project, a detailed introduction of our educational materials, and our recommendations based on our findings. By completing this project, we hoped to help local municipalities better regulate their stormwater runoff, and in turn keep the local surface water bodies free from pollution.

2.0 Literature Review and Background

Water is indispensable to human life. Roughly 70% of an adult's body is made up of water (USEPA, 2016f), and about 70%-75% of the earth's surface is covered with water. Despite the fact that most people understand the importance of water, the main cause of water pollution is human activity.

In the United States, stormwater is one of the leading sources of water pollution (American Rivers, 2014). Unlike wastewater, stormwater usually flows into the surface water without any treatment. Just the nitrogen content in the stormwater runoff alone can cause algal blooms and kill millions of aquatic life (Center for Watershed Protection, 2003).

In this chapter, we discuss the impacts and causes of water pollution and stormwater runoff. Additionally, we describe government approaches to tackling water pollution, including the Federal Water Pollution Control Act, otherwise known as the *Clean Water Act (CWA)*. One of these methods includes mitigating the impact of stormwater pollution. In section 2.3, we introduce both the 2003 and 2016 *Municipal Separate Storm Sewer System (MS4)* permits, passed pursuant to the CWA. Finally, in section 2.4, we explore educational programs that have assisted municipal officials in making land use decisions and mitigation of stormwater runoff impacts.

2.1 Causes and impacts of water pollution

There are various sources of water pollution, such as global warming, industrial waste, burning of fossil fuel, and stormwater runoff (Enviropol, 2014). This section introduces the causes of water pollution and briefly describes some of the impacts of water pollution.

Global Warming

Global warming can cause the sea level to rise, so saltwater is more likely to move into freshwater areas. In addition, an increase in water temperature will result in the death of aquatic

life which will later lead to water pollution (Rinkesh, 2016).

Industrial Waste

Industrial activity can produce huge amounts of waste which contains toxic chemicals and pollutants. If the industries do not have a proper waste management system and discharge the waste into water bodies, it results in poor water quality in the area (Rinkesh, 2016).

Burning of Fossil Fuel

Burning of fossil fuel produces substantial amounts of ash in the atmosphere. While the ash is mixed with water vapor in the atmosphere, it results in acid rain, which eventually leads to water pollution (Rinkesh 2016)

Although these activities pollute water supplies, stormwater runoff is the primary source of water pollution, and has impacts on human health, ecosystems, animals, and the economy (Enviropol, 2014).

2.2 Stormwater runoff

According to the *United States Environmental Protection Agency (USEPA)* (2015d), "stormwater runoff is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and does not percolate into the ground" (p.1). The contaminated stormwater runoff can contain sediments, organic and chemical nutrients and toxins, oil, and other chemical pollutant, as shown in Figure 3 (USEPA, 2012b). The sediments reduce the amount of light in water that is available for plant growth and decrease the supply of food for aquatic organisms. The nutrients cause excessive growth of plants in lakes and streams, which lead to

Figure 3: Drain Runoff
(Киля.2008)

algae and lower dissolved oxygen levels. The toxic organics may poison living organisms and damage their life processes (Enviropol, 2014). In the next section, we show examples of the impact of stormwater runoff and the gravity of this problem.

2.2.1 Impact of stormwater runoff

Contaminated stormwater runoff has serious impacts on water quality, and can lead to algal blooms, which later result in "dead zones". Dead zones and other impaired water bodies that are caused by stormwater runoff can have a serious impact on human health, aquatic life, ecosystem, and the economy.

When the nitrogen pollution carried by stormwater runoff flows from upstream into larger water bodies, it becomes extremely harmful to the aquatic ecosystem. The nitrogen assists in the growth of algae, which in turn leads to algal blooms (Enviropol, 2014). The water bodies with algal bloom are a threat to human health. Many municipal drinking water supplies come from surface water sources, including lakes and rivers. In the United States, the most common water-borne illnesses come from Legionella and Campylobacter bacteria found in polluted drinking water sources (CDC, 2013). In addition, algae not only release dangerous toxins, but also consume oxygen and deplete the supply available to aquatic life when decomposing. Those aquatic ecosystems that contain little to no oxygen are called "dead zones" (NOAA, 2008).

Figure 4: Algal Bloom
(F. Andrews, 2005)

Dead zones affect not only human health and animal's survival, but can also affect a country's economy. The government needs to spend a lot more to purify drinking water coming from a polluted water body (ESA, 2016). Commercial fishing is also negatively affected due to the decrease of fish and the toxins in the water that algae release (Enviropol, 2014). Moreover, polluted water bodies can cause a loss of tourism. According to the USEPA's (2012b) report, "the U.S. tourism industry loses close to $1 billion each year, mostly from losses in fishing and recreational activities because of nutrient-polluted water bodies" (p.6). In the United States, the Gulf of Mexico dead zone (see Figure 5), located off the coast, is the second largest dead zone in the world. To fix the Gulf dead zone, it could cost the U.S. government up to $2.7 billion a year (Johnson, 2015).

Figure 5: The Gulf of Mexico Dead Zone (NOAA, 2016)

2.3 Methods to address water pollution

To address water pollution problems, the United States Congress has passed several environmental laws. Of particular importance to our research and the issue of stormwater pollution is the Federal Water Pollution Control Act (USEPA, 2016e).

2.3.1 Clean Water Act

In 1948, Congress passed the *Federal Water Pollution Control Act (FWPCA),* the first major United States Law to address water pollution and water quality (USEPA, 2015b). In 1972, Congress amended the FWPCA to regulate the discharges of pollutants into surface water bodies and set water quality standards, and the law became known as the Federal CWA (USEPA, 2015e). Pursuant to the CWA, the USEPA was given the authority to implement pollution control programs,

such as setting wastewater standards for industry and water quality standards for all contaminants in surface water.

The purpose of the CWA is to maintain the chemical, physical, and biological integrity of surface water by limiting harmful pollutants from entering surface water bodies (Muskie, 1978). In order to accomplish this goal, the 1972 amendments to the CWA established the *National Pollutant Discharge Elimination System (NPDES)* (Wagner, 2006). The NPDES program's main focus is to regulate the amount of pollutant discharges into a surface water body from a point source, and the program gives permission to the USEPA to record the quality of surface water bodies.

2.3.2 Point source discharges

The CWA and its accompanying regulations regulate the discharge of pollutants into a surface water body from a point source pursuant to the NPDES permitting program (USEPA, 2016d).

The USEPA defines point source pollution as "any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship, or factory smokestack" (Hill, 2010, p.316). Two common types of point sources are the pipes that come out of factories and sewage treatment plants. Many factories typically discharge one or more pollutants, called effluents, directly into water bodies, but some treat effluents before they are released to sewage treatment plants.

Conversely, other pollution comes from nonpoint sources (USEPA, 2012a). Unlike point source pollution, which comes from sewage treatment plants, agricultural runoff, and industrial

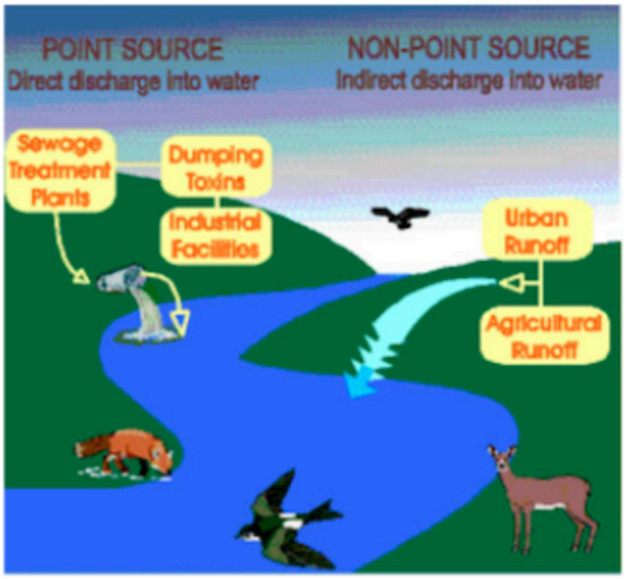

Figure 6: Point and Nonpoint Source Pollution (Lake Forest College, 2014)

sites, non-point source pollution, often termed 'diffuse' pollution, occurs over a wide area and is not easily attributed to a single source. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground. The water carries away natural and human-made pollutants and deposits them into lakes, rivers, etc. (USEPA, 2016k). A good example of both point and nonpoint source pollution is shown in Figure 6.

2.3.3 Municipal separate storm sewer system permit

When stormwater flows over pervious surfaces, such as soil or grass, it can naturally penetrate into the ground, be naturally filtered by the soil, and flow into the groundwater. Urbanization has increased the area of surfaces that are impervious, or impenetrable. In an effort to reduce the amount of stormwater runoff, many urbanized areas have *Municipal Separate Storm Sewer Systems (MS4s)*, which are systems of conveyances to collect rainwater from streets and reroute it to local waterways (Saltzman, 2012).

Once stormwater runoff travels into a local MS4, the runoff becomes a point source, which is under the regulatory authority of the NPDES permit program. The point at which stormwater is discharged into a surface water body is called an outfall. There are hundreds of outfalls that can often lead into rivers or other bodies of water. For example, the town of Dedham, Massachusetts, has about 1,000 different outfalls that feed into different bodies of water (F. Civian, personal

communication, April 11, 2016). The result of numerous catch basins and outfalls in urbanized areas can result in complex stormwater management systems.

Some municipalities have combined wastewater and stormwater systems, known as *Combined Sewer System (CSS)*. A CSS collects rainwater runoff, domestic sewage, and industrial wastewater into one pipe (USEPA, 2016a). Having a CSS is rare, and most municipalities have separate stormwater sewer systems. Trying to treat stormwater runoff as well as wastewater is not an ideal option, because it is not practical to filter large amounts of water in a timely and cost-efficient method (USEPA, 2015c). For example, in Cambridge, Massachusetts, a combined pipeline is used, which controls stormwater runoff and waste at the same time (F. Civian, personal communication, April 11, 2016). If there is a heavy rainstorm, the pipes start to back up, which results in untreated wastewater entering water bodies, as shown in Figure 7. This event is referred to as a *Combined Sewer Overflow (CSO)* (NOAA, 2008).

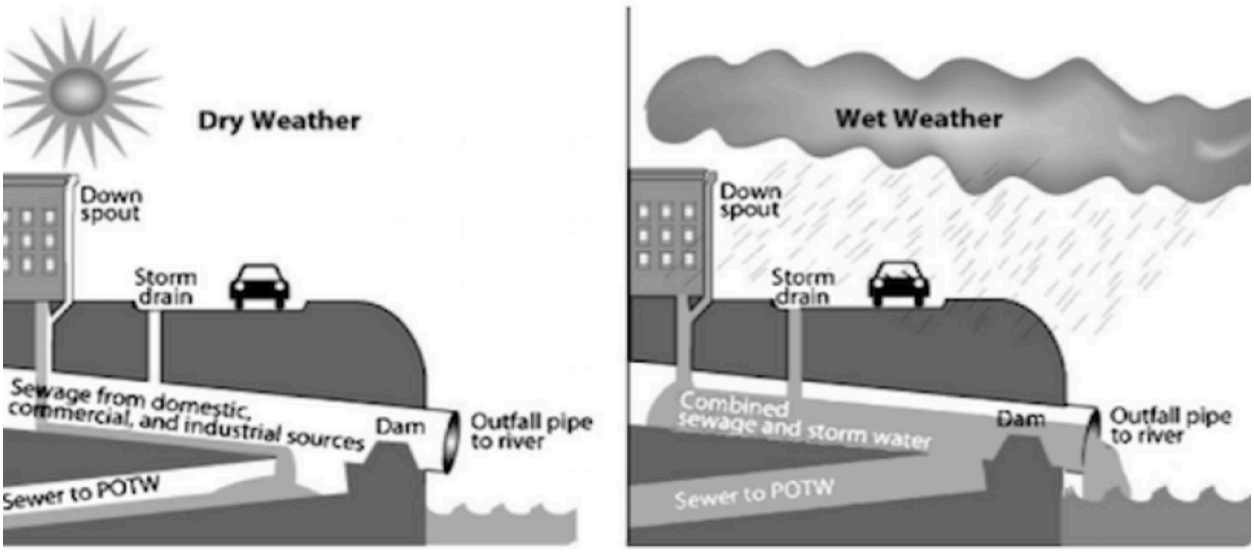

Figure 7: Combined Sewer System
(USEPA, 2004)

When pollutants flow into catch basins, they often end up in a body of water, which harms the quality of the water and other life forms that rely on that water source. Although one outfall in a water body may not be a serious threat to the water quality, a large number of outfalls emptying into a body of water can result in major environmental problems (USEPA, 2015c).

In 1990, the USEPA released the MS4 permit to specifically deal with stormwater management. In 1999, the USEPA (2016f) established the Phase II MS4 regulation, which covers small MS4s in towns and cities. A small MS4 is a separate storm sewer system located in an urban municipality with fewer than 100,000 residents (USEPA, 2016f). On May 1, 2003, the USEPA (2003) issued its *Final General Permit for Stormwater Discharges From Small Municipal Separate Storm Sewer Systems* (2003 MS4 permit), which provides regulations for managing MS4s in Massachusetts and New Hampshire. These requirements are broken down into six minimum control measures.

The updated 2016 General MS4 permit, released on April 4, 2016, contains a few notable changes from the original 2003 permit. The 2016 permit is only issued for MS4 operators in Massachusetts, and not for operators in New Hampshire, whereas the 2003 permit was issued for operators in both states (USEPA, 2003; USEPA, 2016d). The 2016 permit lists major surface water bodies and the towns that have MS4s discharging into them. In terms of the six minimum control measures, the 2016 permit sets forth additional and more detailed regulations for each of the six categories (USEPA, 2016d).

As mentioned above, the requirements set forth in the Phase II General MS4 Permit are categorized into six "minimum control measures" (USEPA, 2016d). They are:

- First (1st) - Public Education and Outreach
- Second (2nd) - Public Involvement and Participation
- Third (3rd) - Illicit Discharge Detection and Elimination
- Forth (4th) - Construction Site Stormwater Runoff Control

- Fifth (5th) - Post Construction Stormwater Management
- Sixth (6th) - Good Housekeeping and Pollution Prevention for Permittee Owned Operations

The first minimum control measure is **public education and outreach**. This measure requires towns to provide educational materials for the community, and outlines what information the materials need to contain for a variety of community audience--residents, businesses, developers, and industrial facilities. The **public involvement and participation** measure states that people in the community must be able to volunteer, and that they may, and are encouraged to, form a stormwater management committee. The third measure, **illicit discharge detection and elimination *(IDDE)***, requires the municipality to prohibit illicit discharges and *Sanitary Sewer Overflows (SSOs)* from entering the municipality's MS4. Illicit discharges are any discharges entering an MS4 that are not entirely stormwater. The next two control measures, **construction site storm water runoff control** and **post construction storm water** state that programs similar to the illicit discharge program must be developed to manage stormwater resulting from construction projects. The final minimum control measure, **good housekeeping and pollution prevention for permittee owned operations**, states that the municipality must implement a maintenance program with the goal of reducing the amount of pollutants entering surface water bodies. Additionally, it includes a set of regulations for managing and maintaining MS4s.

An IDDE program must be implemented as set forth in the 2016 General MS4 permit. The permit contains additional requirements for the program, and a set of minimum requirements that the program must comply with. Of note to this project is that a plan must be developed and implemented to detect and mitigate non-stormwater discharges from entering the system (USEPA, 2003). The 2016 MS4 permit (USEPA, 2016d) adds additional requirements for SSOs. Within one year, the municipality must identify all locations where SSOs have discharged over the past five years, and must take measures to fix the appropriate systems to make sure they do not continue.

The USEPA (2016g) is the agency that has been authorized by the U.S. Congress to administer and establish regulations in the MS4 permit. The USEPA (2016f) is the regulator and enforcer. As a state environmental agency, the *Massachusetts Department of Environmental Protection (MassDEP)* (2016c) acts as an educational liaison between Massachusetts municipalities and the USEPA. Some municipalities prefer to work with MassDEP because they already have a relationship with Massachusetts municipal officials. The MassDEP is a co-signatory for the permit to ensure that they continue to be involved in the discussion of how the permit should be implemented.

During the comment period for the 2013 Draft New Hampshire MS4 permit, many New Hampshire municipalities expressed concerns about the requirements in the MS4 permit becoming a significant administrative and financial burden (City of Portsmouth, 2013). Since the 2013 Draft New Hampshire MS4 permit is very similar to the 2016 Massachusetts MS4 permit, the comments exposed some fears that the central Massachusetts municipalities might have when the new permit becomes effective. For example, the City of Portsmouth, New Hampshire (2013) estimated that about 2,800 additional staff hours and an additional $3,500,000 over the five-year permit cycle would be required to comply with the 2013 Draft MS4 NPDES permit. Since the City budget was not likely to increase, the City of Portsmouth (2013) would have to cut or reduce the budget from other essential program.

Due to the budget and labor limitations, many municipalities in New Hampshire were concerned with the time limit in the draft permit (Town of Londonderry, 2013). Some other concerns with the 2013 draft MS4 Permit include no measurable impacts, repetition with other regulations and no templates for the education of stormwater issues (Massachusetts Coalition for Water Resource, 2013).

Given the concern with understanding and complying with all the new requirements, it is essential to educate Massachusetts municipal officials about the new 2016 MS4 permit so they can start to plan for and implement necessary changes to their MS4s. According to a comprehensive cost analysis of the 2014 Draft MS4 permit, municipalities should expect a significant increase in their financial output for stormwater management in order to meet the new permit requirements (Correia, E. J., Giroux, M. J., & Peterson, C. D., 2014). According to Correia, et al., the current costs that three central Massachusetts towns spend annually to meet the 2003 MS4 permit range between ~$180,000 and $580,000. Correia, et al. estimated that the annual costs for all three towns would be significantly higher under the 2014 Draft MS4 permit, as shown below in Table 1, ranging from ~$260,000 to $750,000. The report also found that towns must set aside a considerable amount of money for one-time and intermittent costs. The one-time costs are for any item that must only be completed once over the permit term, such as completing and submitting the *Notice of Intent (NOI)*. Intermittent costs cover any items that occur sporadically, such as catch basin cleaning.

Town	**Southbridge**	**Holden**	**Millbury**
2003 Permit Total Costs	**$268,604/yr.**	**$186,526/yr.**	**$584,960/yr.**
Annual	$268,604/yr.	$186,526/yr.	$584,960/yr.
2014 Draft Permit Total Costs Annual/yr. + (One-time + Intermittent)	**$343,008/yr. + $372,816**	**$258,790/yr. + $383,304**	**$753,173/yr. + $402,441**
Annual	$343,008/yr.	$258,790/yr.	$753,173/yr.
One-Time	$314,940	$325,428	$320,231
Intermittent	$57,876	$57,876	$82,210

Table 1. Estimated costs for the 2003 and 2014 Draft MS4 permits
Data from (Correia, E. J., Giroux, M. J., & Peterson, C. D., 2014)

2.4 Methods to educate municipal officials about MS4 permit

Some states' organizations and institutions have developed outreach programs for educating municipal officials about MS4 permits. *Massachusetts Watershed Coalition (MWC)* and the *Central Massachusetts Regional Stormwater Coalition (CMRSWC)* are organizations that offer municipalities assistance, either through workshops or educational materials, with stormwater management and compliance with MS4 permits. The National *Nonpoint Education for Municipal Officials (NEMO)* Network is also an outstanding example of a university based program designed to assist municipal officials with land use decisions, primarily around stormwater management (Dietz, 2016; UMN, 2016).

2.4.1 MWC and CMRSWC

The MWC and the CMRSWC are two coalitions in Massachusetts that focus on improving municipalities' stormwater management and provide town officials with assistance on MS4 permit compliance. The MWC was formed in 1991 and has community partners across Massachusetts. The goal of the MWC is to protect the watershed ecosystem. The MWC holds workshops that allow town officials in charge of stormwater management from different Massachusetts municipalities to discuss their concerns about the MS4 permit. The MWC also has workshops that share information about stormwater management, including cost analysis (MWC, 2016). The CMRSWC is a Coalition of 31 communities in central Massachusetts with the goal of helping member communities comply with the 2016 Massachusetts MS4 permit. The CMRSWC allows its members to share resources and provides its members with technical assistance, such as a *Geographic Information System (GIS)* tool known as PeopleGIS (CMRSWC, 2016) (see Appendix A for background of the CMRSWC).

2.4.2 NEMO programs

The NEMO Program was started in 1991 at the University of Connecticut (2016). Given the impact that land use decisions have on the community, the program was set up to make sure local officials could make well informed decisions with regards to the environment. This program targets local land use officials and strives to increase town officials' knowledge about "the connection of land use and management decisions to water quality and natural resources" (UMN, 2015, p.1). There are now several successful NEMO programs all over the United States including programs in Connecticut, Minnesota, Wisconsin, New Hampshire, and Rhode Island. As the program has expanded nationally, different states' NEMO programs developed different methods to educate local town officials.

Well-developed educational tools and customized workshops are key points that make the CT NEMO program unique (Dietz, 2016). The tools that the CT NEMO program has developed include a mobile phone application called "Rain Garden", Connecticut *Low Impact Development (LID)* Regulations Inventory, and an online interactive watershed map. These tools use *Geographic Information System (GIS)* and remote sensing technology to help provide accurate information about local natural resources so the municipal officials can use it for land use planning. The CT NEMO program uses face-to-face customized workshops for local officials as their primary educational method (Dietz, 2016). The CT NEMO program offers stormwater management workshops to area municipalities. These workshops educate local officials on how to mitigate the impact of stormwater, especially in urban areas. The CT NEMO workshops work well for town officials because the CT NEMO puts lots of effort into developing the most suitable workshops for each town. The CT NEMO workers go to town halls to communicate with target

audiences about the format and the content of the workshops to ensure the relevancy of the workshops (Dietz, 2016).

The Northland NEMO represents a collaboration of organizations in Minnesota and Wisconsin (UMN, 2015). The Northland NEMO works with the Minnesota Extension *Stormwater Education Program (SEP)* to develop educational materials for town officials. Although the SEP does not have many tools developed on their website, they have a well-developed technology series that provides education on tools and computer models (UMN, 2016). Moreover, the Northland NEMO developed an interactive, educational tool called the "Watershed Game" that helps different audiences understand the connection between land use and water quality (UMN, 2015). The Northland NEMO holds their workshops with town officials on buses or boats to help emphasize the impacts that their decisions can have on the local land, and to ensure the town officials have a livelier experience.

The Rhode Island NEMO focuses on developing educational websites that include tips for the general public about simple daily actions that can help eliminate stormwater pollution (University of Rhode Island, 2016). The NEMO program in New Hampshire is also called New Hampshire *Natural Resources Outreach Coalition (NROC)*. On their website, the NROC provides educational materials about how to protect different natural resources (University of New Hampshire, 2016).

All the NEMO programs in different states provide good examples of different methods for educating town officials. The choice of most applicable educational material depends on town officials' preference and the town's resources. Although NEMO works with municipal officials to educate them about MS4 permit compliance, among other land issues, they are ultimately not responsible for implementing the necessary changes to meet the MS4 permit requirements.

2.5 Research gap and summary

On July 1st, 2017, the 2016 Massachusetts Small MS4 general permit will become effective. This gives municipalities in Massachusetts little time to prepare for the more stringent requirements in this permit. Although there is a lot of research on impacts and changes in the upcoming 2016 MS4 permit, central Massachusetts municipalities do not have a well-developed education program like the NEMO programs that targets local officials and provide these officials with education, information, and assistance to help them prepare for the permit. *Worcester Polytechnic Institute's (WPI) Worcester Community Project Center (WCPC)* is an off-campus project center that offers students the opportunity to help tackle community issues. The WCPC connected us with the MassDEP and the CMRSWC and provided us a chance to work on environmental issues in our community. In the next chapter, we explain how we worked with the MassDEP and the CMRSWC to develop a suitable tutorial system for central Massachusetts municipal officials to educate them about stormwater pollution and the 2016 MS4 permit. We hope our work will have a significant impact on stormwater runoff management in Massachusetts to help protect surface water bodies from pollution.

3.0 Methodology

The goal of our project, in collaboration with the *Massachusetts Department of Environmental Protection (MassDEP)*, the *Central Massachusetts Regional Stormwater Coalition (CMRSWC or the Coalition)*, and the town of Holden, was to assist central Massachusetts municipalities in complying with the 2016 *Municipal Separate Storm Sewer System (MS4)* permit by developing educational material that address the areas of the permit municipalities are most concerned with. We also worked with the town of Holden to develop a public outreach and education video that could be duplicated by other municipalities. To achieve our goal, we completed the following five objectives:

- Objective 1: Identify changes between the 2003 and 2016 MS4 permit;
- Objective 2: Identify areas of the permit that municipalities in other states, including Connecticut, New Hampshire, Minnesota, and Rhode Island have struggled with, and areas that central Massachusetts municipalities anticipate struggling with;
- Objective 3: Identify how other states have educated municipalities about MS4 permit requirements and determine most appropriate educational method for central Massachusetts municipalities;
- Objective 4: Develop educational materials using findings from objectives 2 and 3; and
- Objective 5: Create and document the process of creating a video for the town of Holden residents about stormwater runoff to help comply with the "Public Education and Outreach" minimum control measure.

Below, we describe the methods we used to achieve each objective.

Objective 1: Identify changes between the 2003 and 2016 MS4 permit

We gained a solid understanding of the 2016 Massachusetts MS4 permit requirements and how the 2016 MS4 permit differs from the previous MS4 permit by comparatively reading and analyzing the 2003 and 2016 MS4 permits (Bernard, 2011). In addition, we consulted with Frederick Civian, the MassDEP Stormwater Coordinator; and Newton Tedder, a *United States*

Environmental Protection Agency (USEPA) employee and the drafter of the 2016 MS4 permit, on the meaning of ambiguous terms. Finally, we developed a table comparing the differences between the two permits.

To develop the table, we first analyzed the 2003 MS4 General permit and 2016 Massachusetts Small MS4 General permit. We conducted a semi-structured interview with Mr. Civian and Mr. Tedder to clarify the possible ambiguous language in the permit and give the requirements more measurable standards. We put ourselves in the position of municipalities and found that some of the due dates, references, and terms like "evidence of effectiveness" and "environmental impact" can be ambiguous to town officials (see Appendix B: Sample interview protocol). We conducted an in-person interview with Mr. Tedder in Boston because it is important for us to understand the permit accurately before we develop materials intended to assist town officials with MS4 compliance (Bernard, 2011).

Isabel McCauley, a Senior Civil Engineer of Holden *Department of Public Work*s *(DPW)*, provided us with a table of the changes between the 2003 and 2014 Draft MS4 permits. Using the table provided by Ms. McCauley as a starting point, we created a table of changes between the 2003 and 2016 MS4 permits. The table of changes helped us discern which areas of the permit central Massachusetts municipalities may need assistance with.

Objective 2: Identify areas of the permit that municipalities in other states, including Connecticut, New Hampshire, Minnesota, and Rhode Island have struggled with, and areas that central Massachusetts municipalities anticipate struggling with

The CMRSWC member municipalities already have many resources that are being used to comply with the 2003 MS4 permit, and for other aspects of stormwater management. We wanted to find out what resources the Coalition did not already have, what problems other states struggled with, and what areas of the permit municipal officials might need more assistance with. To find

out the challenges in MS4 permit compliance, we interviewed state agencies, organizations and institutions, which work with municipal officials on stormwater management, in Connecticut, Massachusetts, Minnesota, New Hampshire and Rhode Island. In addition, we also developed a survey for the members of the CMRSWC. Through the information from interviews and the survey, we identified the areas that central Massachusetts municipalities anticipate struggling with when complying with the 2016 MS4 permit and could use more assistance.

At the beginning of our project, we conducted unstructured interviews with Mr. Civian; Corey Dehner, our project advisor and the co-director of the *Massachusetts Water Resource Outreach Center (WROC);* and Andrea Briggs, our co-sponsor and the MassDEP outreach coordinator. The Massachusetts WROC is an off-campus project center that provides students with the opportunity to work with eastern and central Massachusetts municipalities on solving water protection issues (WPI, 2016). During the interviews, we asked Ms. Briggs and Mr. Civian about the difficulties that central Massachusetts municipalities are facing from the perspective of the MassDEP, a state environmental agency (See Appendix A: Sponsor information). In addition, we got suggestions and contact information from Ms. Briggs, Mr. Civian, and Ms. Dehner about the choice of interviewees who might help us identify the towns' obstacles in implementing the 2016 MS4 permit. With Ms. Briggs, Mr. Civian, Ms. Dehner acting as the liaisons, we conducted more interviews with the *Nonpoint Education for Municipal Officials (NEMO)* programs (See section 2.4 for information about NEMO), *Massachusetts Watershed Coalition (MWC)*, *New Hampshire Department of Environmental Services (NHDES)*, and the town of Holden. We also attended a USEPA workshop and the CMRSWC Steering Committee meeting with Ms. Briggs and Mr. Civian (see Appendix A: Sponsor information).

The May 24th, 2016 workshop, held by the USEPA and the MassDEP, provided attendees with information on the 2016 MS4 permit requirements. During the workshop, we heard different cities' and towns' insights about the permit itself, how to comply with the permit requirements, and clarification on some of the requirements. The workshop was also helpful because we learned areas of the permit that towns and cities were having difficulty complying with and how some towns and cities were able to manage the permit requirements.

We interviewed the directors of the Connecticut, Northland (Minnesota and Wisconsin), and Rhode Island NEMO programs; along with Ed Himlan, the Executive Director of the MWC; and Jeffrey Andrews, an employee of the NHDES. All the interviewees are working on teaching town officials about stormwater management which is what we were trying to help with in Massachusetts. We chose to conduct the interviews via phone because it was a small group of six interviewees who are very busy and live outside Worcester, Massachusetts (Bernard, 2011). We developed semi-structured questionnaires for each interviewee. The semi-structured interview allowed the interviewees to talk freely about their suggestions on our project, and also helped us gather particular information about the organizations or programs they represented and the difficulties of running workshops for town officials (Bernard, 2011).

For each interviewee, we shared our interview questions with them prior to the interview so that they had some time to prepare for the questions, and give us more thoughtful answers. When sharing the interview questions, we also asked for interviewees' permission to record the interviews so that we had access to all the interview transcripts for analysis later (Bernard, 2011). We developed the questions to be similar; the main core of questions was always the same, while the last two to three questions were customized for that particular interviewee. This way, we could easily compare the data from the interviews and also get enough information about the

differences among the organizations. After recording all the interviews, we analyzed the interview transcripts and came up with a list of challenges that other states were facing (see Appendix B: Sample interview protocol).

In addition to conducting interviews, we developed a survey for the members of the CMRSWC Steering Committee. We surveyed 13 of 30 CMRSWC members, who are stormwater management representatives from different communities in central Massachusetts, in order to gain insight into what municipal officials believe to be the most challenging portions of the 2016 MS4 permit (see Appendix C: Survey). We prepared an electronic link to the survey and an informational email to the CMRSWC, but had Ms. Briggs and Mr. Civian send out the survey on our behalf because the Coalition members were more likely to respond to officials from state agencies than college students. We also distributed the paper survey during the June 7th, 2016 CMRSWC Steering Committee meeting to increase our survey response rate. We believed that people may be more likely to respond to an in-person survey request than an email request (Bernard, 2011).

We compiled the interview transcripts and survey responses into a usable format. We then analyzed the data looking specifically for areas that municipalities have or anticipate struggling with when complying with the 2016 MS4 permit (Bernard, 2011).

Objective 3: Identify how other states have educated municipalities about MS4 permit requirements and determine most appropriate educational methods for central Massachusetts municipalities;

During our interviews with the NEMO based programs and watershed organizations, in addition to asking about areas of the permit that municipalities struggle or anticipate struggling with (see Objective 2 for interviews details), we investigated what these organizations have done or plan to do to assist the municipalities with overcoming these challenges. From the interviews,

we discovered various existing educational methods which have been used to teach municipal officials about stormwater management. Using our findings, we identified the most applicable educational methods for central Massachusetts municipalities.

We received lots of helpful information and tools on methods to educate municipal officials. One organization that might have been of particular help was the *New Hampshire Natural Resources Outreach Coalition (NROC)* program, a NEMO program based in New Hampshire (University of New Hampshire, 2015), since New Hampshire published a new draft of the MS4 permit in 2013. Unfortunately, we were not able to conduct an interview with the NROC due to the limited time frame of our project, but the NROC is a good resource for researching the challenges of Massachusetts MS4 permit compliance.

The information gathered from other states' NEMO programs, including Connecticut, Rhode Island, Minnesota; and the NHDES was helpful when developing specific educational materials for Massachusetts. We chose to interview NEMO programs because of their experience dealing with municipal officials. Additionally, the states that the NEMO programs are located in all have MS4 permits or requirements involving stormwater management. The audience for the materials we created is municipal officials, so we wanted to get as much insight as possible from our interviewees on how to educate and create materials for this audience.

The purpose of objective 3 was for us to gain knowledge and experience on how other states have educated their municipalities on their respective MS4 permit requirements, and the effectiveness of different educational methods.

Objective 4: Develop educational materials using findings from Objective 2 and 3

Using our findings from Objectives 2 and 3, we created educational materials to help municipal officials comply with the 2016 MS4 permit. We further consulted with our sponsors Ms.

Briggs and Mr. Civian to determine which sections of the permit we should create the materials for.

In our interview with Mr. Andrews from the NHDES, he pointed us towards a timeline of all the permit requirements in the 2013 Draft New Hampshire MS4 permit. He found the timeline to be useful for the New Hampshire municipalities since it provides town officials with an easy way to understand *what* they have to do for the permit, and *when* they need to complete the individual requirements by (J. Andrew, personal communication, May 18, 2016).

However, the timeline lacks an explanation on *how* to complete the requirements. After consulting with Ms. Briggs, Mr. Civian and Mr. Tedder we concluded that developing step-by-step instructions would be the best fit for helping the town officials understand *how* to comply with the 2016 MS4 permit requirements (personal communication, May 25; personal communication, May 26, 2016; personal communication, Jun 15, 2016). These instructions outline for the municipality the steps they need to take to meet a particular requirement. Besides the timelines and step-by-step instructions, we created checklists to help municipalities track their progress in complying with the various sections of the permit.

Based on the results of our survey and interviews, we developed a document called MS4 Compliance Guideline, which includes timelines, step-by-step instructions, and checklists. (see Appendix D: Survey report and Appendix E for MS4 Compliance Guideline). From our discussions with Ms. Briggs and Mr. Civian, and given the limited time of our project, we collectively decided to include the first, second, and sixth minimum control measure in the MS4 Compliance Guideline.

To create the timeline, we analyzed the NH MS4 Draft Permit timeline provided by Mr. Andrews, the 2014 Draft MS4 permit timeline distributed by the USEPA and various other

timeline templates. These timelines, although for different MS4 permits, were good references for developing the timelines for the 2016 MS4 permit. To make step-by-step instructions, we researched each requirement, and consulted with Mr. Civian and Mr. Tedder for any ambiguous terms. To create the checklists, we analyzed the relevant permit sections and identified all requirements, including tasks and subtasks.

Once we developed the MS4 Compliance Guideline, we distributed them to a few municipal stormwater officials to determine how well the Guideline worked. Using their feedback, we further revised the Guideline to submit to the CMRSWC and the MassDEP.

Objective 5: Create and document the process of creating a video for the town of Holden residents about stormwater runoff to help comply with the *Public Education and Outreach* minimum control measure

We worked with Ms. McCauley to develop an educational video for the town of Holden referred to as the Holden MS4 educational video. The focus of the video is to make sure the residents of Holden are aware of the impacts of stormwater runoff and educate them on how to prevent poor water quality due to stormwater pollution.

We first developed the storyboard for the video by consulting with James Monaco, an Instructional Media Specialist at *Worcester Polytechnic Institute (WPI)*. After this, we revised the storyboard and created a draft script. We then timed the length of the script, and lined up the talking in the script with the different shots in the storyboard. With the script and storyboard synced up, we were able to determine the length for each shot, and begin creating the video. First, we developed a shot list of all the areas in the town of Holden where we wanted to get footage after consulting with Ms. McCauley, Ms. Briggs, and Juliet Swigor, a *Geographic Information System (GIS)* mapping specialist for the MassDEP, who all live in the town of Holden. We filmed John Woodsmall, the director of Holden DPW reading parts of our script, and we recorded ourselves

reading the rest of the script. We chose to have John Woodsmall read parts of the script, as he is well recognized by the residents of the town, and his words and recommendations for residents have more of an impact than those of a college student. After creating a rough draft of the video, we were able to revise it based on feedback from our sponsors in Holden, and ultimately provide it to the town of Holden for implementation. The purpose of making the video is to help the town of Holden meet the *Public Education and Outreach* minimum control measure.

After completing the video for the Town of Holden, we detailed the video creation process in a document to allow other towns to easily produce an educational stormwater management video and meet their *Public Education and Outreach* requirements. The advantage in developing a town specific video, as opposed to simply redistributing the video we developed, is that a video depicting recognizable locations within a town will have much more of an impact on its residents since they are more likely to connect with footage from their town (see Appendix F for video making procedure).

In completing this project, we learned about many existing methods to help towns comply with the MS4 permit in various states. After analyzing our findings, and gaining a comprehensive understanding of the differences between the 2003 and 2016 MS4 permit in Massachusetts, we developed templates and documents to help towns comply with the permit. In the next chapter, we discuss our findings and results of our work, and provide recommendations to our sponsoring organizations and individual towns on how to best comply with the 2016 Massachusetts MS4 permit.

4.0 Findings

In this chapter, we begin by introducing the general information about the 2016 *Municipal Separate Storm Sewer System (MS4)* permit, including some changes from the 2003 MS4 permit. In the next section, 4.2, we investigate the claims for and against the new requirements in the 2016 MS4 permit, and the necessity of the MS4 permit in general. In section 4.3, we analyze the requirements in the 2016 MS4 permit that central Massachusetts municipalities anticipate struggling with. Towards the end of this chapter, in section 4.4, we explore the resources currently available to municipalities to assist with the 2016 MS4 permit compliance. In addition, we describe methods the *Central Massachusetts Regional Stormwater Coalition (CMRSWC or the Coalition)* could use to assist Coalition members with 2016 MS4 permit compliance.

4.1 General information about the 2016 MS4 permit

On April 4th, 2016, the *United States Environmental Protection Agency (USEPA)* released the 2016 MS4 permit. In this section, we discuss the changes between the original 2003 MS4 permit and the updated 2016 MS4 permit.

Finding 1: The 2016 permit includes more stringent requirements

The 2016 Massachusetts MS4 permit contains more stringent requirements compared to its predecessor from 2003. The 2016 permit contains all the same core requirements as the 2003 permit, however, the amount and detail of requirements has been significantly increased. Of note is the *Illicit Discharge Detection and Elimination (IDDE)* minimum control measure (section 2.3.4 of the permit). In the 2016 permit, the municipality is required to overhaul their MS4 map originally developed under the 2003 permit, which only required the municipality to map outfalls and include names of receiving water bodies. The new permit requires municipalities to map outfalls as well as interconnections with other storm sewer systems, impaired waters, swales,

ditches, pipes, manholes, catch basins, and municipal sanitary or combined sewer system, if applicable (USEPA, 2016). Additionally, the municipality must rank their outfalls based on how likely they are to have an illicit discharge, that is, any discharge that is not comprised entirely of stormwater.

Another section that received a major overhaul in the 2016 permit is *Water Quality Limited Waters* and *Total Maximum Daily Loads (TMDLs)*. TMDLs are a limit, imposed by the USEPA, on the amount of a certain pollutant that is allowed to enter a waterbody (see section 2.2.1 of the permit) Both the 2003 and 2016 permits require the permittee to ensure the stormwater discharges meet *Waste Load Allocations* (*WLAs*) for waters with TMDLs, and that the discharges do not contribute to the pollution of water quality limited waters, that is "any water body that does not meet applicable water quality standards" (USEPA, 2016c, p.22). The 2003 permit was more relaxed in its requirements, and only required that the municipality document how they will meet the WLAs for the impaired waters. The 2016 permit requires the municipality to design and implement a three phase plan over 20 years to meet the specified WLAs. Additionally, the municipality must document and report progress each year towards the plan, and show a decrease in pollutants at the end of each phase.

4.2 Opposing viewpoints of the 2016 MS4 permit

In creating the 2016 MS4 permit, the USEPA wants to improve or maintain good water quality with comprehensive and stringent requirements. However, the municipalities want to have more freedom on taking actions to protect surface water bodies based on the town's or city's status. In addition, most municipalities think it will be difficult to comply with the additional requirements in the 2016 MS4 permit due to their limited resources and the tight deadline. We discuss the views

of both environmental activists and municipal officials on the permit, and discuss concerns that both sides have with the permit.

Finding 2: Providing evidence for the effectiveness of the educational program is vague and difficult for municipalities to implement

Under the 2016 MS4 permit *Public Education and Outreach* minimum control measure, the USEPA requires municipalities to develop an educational program. In the educational program, the municipalities are required to set up an educational goal they want to achieve, establish some specific messages they plan to send to the public, and identify who will be responsible for implementing the program. Each municipality is also required to provide methods for measuring and evidence of the effectiveness of the educational program, where 'effectiveness' refers to a measurable positive impact on the quality of water in the area (N. Tedder, personal communication, May 26, 2016).

Since the requirements under *Public Education and Outreach* in the 2016 MS4 permit are the same as the requirements in the 2014 Draft Massachusetts Small MS4 general permit, municipalities' and organizations' comments to the USEPA on the 2014 Draft permit show municipal officials' concerns about the requirements. The town of Watertown commented that the effectiveness evaluation requirement is "vague and need[s] to be clarified" (USEPA, 2014a). Out of the 53 comments on *Public Education and Outreach* sent to the USEPA, 31 of them shared this concern. Over 10 of 31 comments suggested that this requirement is "an inefficient use of resources" for individual municipalities (USEPA, 2014a, p.117). The towns of Uxbridge and Lexington, the Northern Middlesex Council of Governments, and Holden Town Manager and Board of Selectmen think that the USEPA should just remove this requirement (USEPA, 2014a). Also, over seven (7) of 31 comments claimed that the "effectiveness is regional" and this

requirement of measuring effectiveness should be taken care of by the USEPA or other regional organizations instead of by individual municipalities.

Another difference of opinion between central Massachusetts municipalities we spoke with and the USEPA is what should be considered valid evidence of environmental impact. The municipalities believe that "quantifiable data such as the number of brochures distributed, the number of hits on a website, or the number of public attendees at MS4 sponsored events" (USEPA, 2014a) should be considered valid evidence. Some town officials and Andrea Briggs, the *Massachusetts Department of Environmental Protection (MassDEP)* outreach coordinator, suggest that the public's overall understanding about stormwater runoff and its impact is very limited. Most of the public still believes that water that goes into storm drains will enter a treatment plant (A. Briggs personal communication, June 8, 2016). Therefore, Ms. Briggs believes that quantifiable data such as the number of viewings of a stormwater educational video should count as illustrating that the public has, at least, been exposed to accurate information about stormwater runoff, and those viewers may in turn, change their behavior (personal communication, June 8, 2016).

However, the USEPA holds that this kind of data is just a support for interim milestones, and does not show the effectiveness of an educational program. In order to get the type of evidence that the USEPA considers to be valid, over 12 of 31 comments, including comments from the town of Framingham, claimed that the USEPA should provide more guidance on the methods for measuring the effectiveness, however, there are still no examples in the 2016 MS4 permit on how to measure effectiveness of educational messages (USEPA, 2014a).

Finding 3: Water preservation organizations' worries about the reduction of requirements from the 2014 Draft MS4 permit

The 2014 Draft MS4 permit, although very similar to the 2016 MS4 permit, contained

some sections with more stringent requirements for municipalities. In the time between the release of the draft and final permits, there were multiple public comment periods. Given that many municipalities pushed back against the IDDE program, the USEPA made the IDDE requirements more relaxed in the final permit (USEPA, 2014b; USEPA, 2016c). Additionally, the timeline for many requirements were extended to give municipalities more time to meet the requirements.

Ian Cooke, executive director of the Neponset River Watershed Association, expressed concern about relaxing the IDDE requirements. He noted that the MS4 permit is absolutely critical for the Neponset River, as it has many water quality impairments; an exceedance of a certain pollutant. Stormwater runoff is the cause for the majority of the impairments (I. Cooke, personal communication, June 10, 2016). Of particular concern to him is the fact that Massachusetts municipalities now have ten years to complete the IDDE requirements, as opposed to five years under the draft permit. This means that there will be illicit discharges to the Neponset River for another five years, thus further impairing it. Additionally, Mr. Cooke is concerned that the intermediate goals have been removed. These goals, found in section 2.3.4.8 of the 2014 Draft MS4 permit, required the municipality to make progress each year towards outfall screening. As a result of the removal of intermediate goals, he said that some municipalities may not start implementing the program until the end of the permit term, leaving these towns with too much in too short a time period, as happened under the 2003 MS4 permit.

Julie Wood, project director of the Charles River Watershed Association; and Ed Himlan, director of the *Massachusetts Watershed Coalition (MWC)* both noted they pushed for shorter timelines (E. Himlan, personal communication, June 17, 2016; J. Wood, personal communication, June 17, 2016). Ms. Wood claimed that most environmental groups pushed for shorter timelines as well. Another change from the 2014 Draft MS4 permit to the 2016 MS4 permit that Mr. Cooke

noted the Neponset River Watershed Association was disappointed about was "the reduction of the required treatment volume for redevelopment projects" (I. Cooke, personal communication, June 10, 2016). In the 2014 Draft permit, redeveloped sites had to either retain or provide an adequate level of pollution removal for the first inch of runoff from impervious surfaces (USEPA, 2014b). However, in the 2016 permit, redeveloped sites only need to retain the first 0.8 inches of stormwater runoff (relative to the size of the impervious area) (USEPA, 2016c).

4.3 Challenges with MS4 compliance

Given the increase in requirements in the 2016 MS4 permit, Ms. Briggs and Mr. Civian anticipate municipalities will face challenges in meeting all of the 2016 permit requirements in time (personal communication, April 11, 2016). In this section, we discuss both the permit sections municipal officials have found to be most troublesome, and the biggest shortcomings municipalities have in complying with the permit.

Finding 4: The most difficult items to comply with in the 2016 MS4 permit are GIS mapping, IDDE, and water quality impaired waters

The three permit items that towns will have the most difficulty complying with are *Geographic Information System (GIS)* mapping, *Illicit Discharge Detection and Elimination (IDDE)*, and water quality impaired waters. We came to this conclusion after interviewing various stormwater management experts, consulting with our sponsors at the MassDEP, and reviewing the results of the survey we sent to the CMRSWC Steering Committee.

In our survey, we asked respondents if they are "concerned about [their] ability to comply with the 2016 MS4 general permit minimum control measures". Of the 13 out of 30 respondents, nine (9) said they were "most concerned" about the IDDE control measure. No other control measure received nearly as many marks for "most concerned." The next closest was the *Post Construction Stormwater Management* minimum control measure. Four (4) of the 12 respondents

noted that they were "most concerned" with this minimum control measure. Figure 8, below, shows how many respondents indicated "most concerned," "somewhat concerned," "not concerned," or "don't know" about their town's ability to comply with the six minimum control measures.

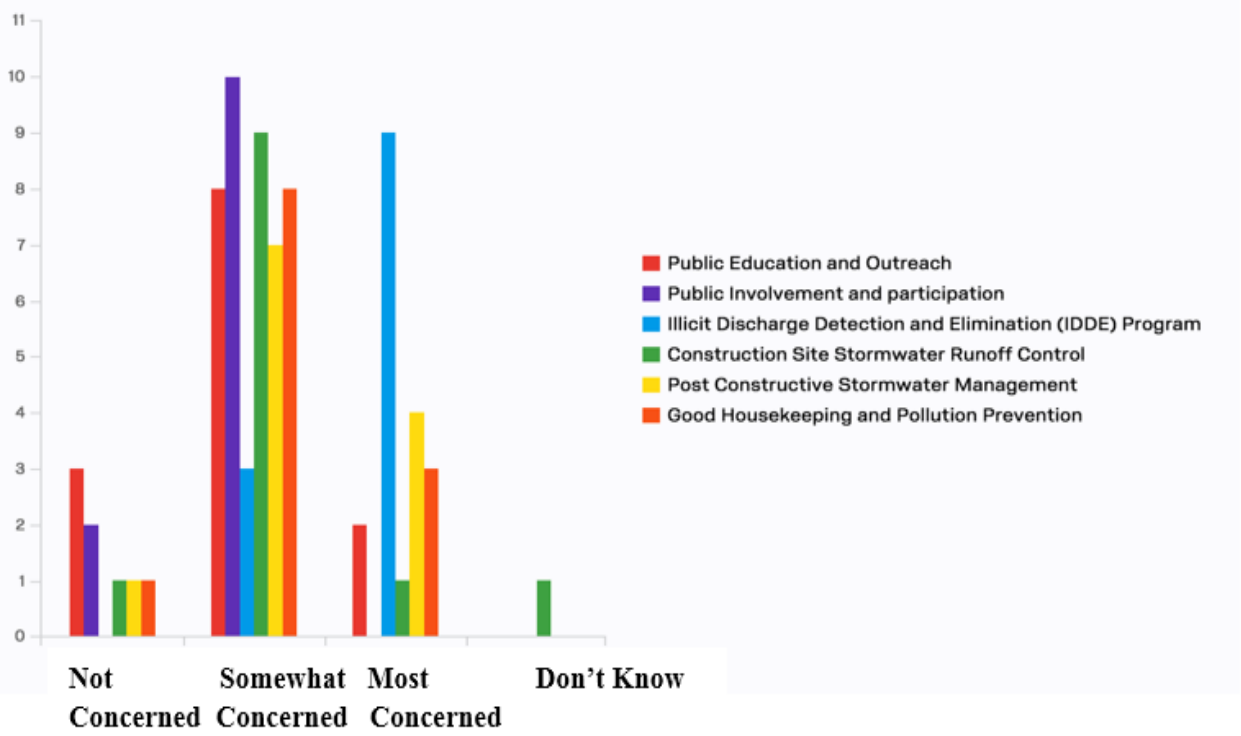

Figure 8. Survey Results for Question 6 in "Survey for the CMRSWC Steering Committee"

John Billota, the director of the Northland *Nonpoint Education for Municipal Officials (NEMO)* program in Minnesota and Wisconsin explained that the Minnesota Pollution Control Agency updated the Minnesota MS4 permit from the initial 2003 permit on May 22nd, 2013. (personal communication, May 26, 2016; Minnesota Pollution Control Agency, 2016). We asked Mr. Billota what the largest undertakings were for NEMO during the first year following the updated permit's release. He said that the highest priority items were IDDE and *Total Maximum Daily Load (TMDL)*, part of water quality limited waters (personal communication, May 26, 2016).

Jeffrey Andrews, an employee of the *New Hampshire Department of Environmental Services (NHDES)* Wastewater Engineering Bureau, explained that "small towns … don't have technical expertise, so they have difficulty with mapping and the GIS, and the IDDE program" (personal communication, May 18, 2016). This supports the evidence from our survey that the IDDE program will likely be the most difficult minimum control measure to implement, and will thus be one of the more difficult sections of the permit.

Although New Hampshire has not yet released an updated permit, they released a draft permit in 2013. Mr. Andrews expects all towns to have trouble with the impaired water and water quality limited waters requirements, as they are going to be very difficult to comply with (personal communication, May 26, 2016).

Finding 5: In trying to comply with the 2016 MS4 permit, Central Massachusetts municipalities struggle with: too few personnel, limited budget, and availability of necessary equipment.

While conducting research and working with municipal officials for over a month, MassDEP employees and Coalition members all pointed to limited budget, too few personnel, and availability of equipment as the three biggest obstacles that central Massachusetts municipalities are facing in their efforts to fully comply with the 2016 MS4 permit.

Our survey results illustrated that (see Appendix C: Survey) Coalition members, who work on and are responsible for the compliance of MS4 permits, found that the top three obstacles municipalities anticipate facing are too few personnel, limited budget, and availability of equipment. Out of 13 respondents, 12 indicated their municipality does not have enough personnel to carry out necessary tasks; nine (9) pointed to financial reasons and seven (7) selected "Availability of necessary equipment" as a shortcoming (see Figure 9).

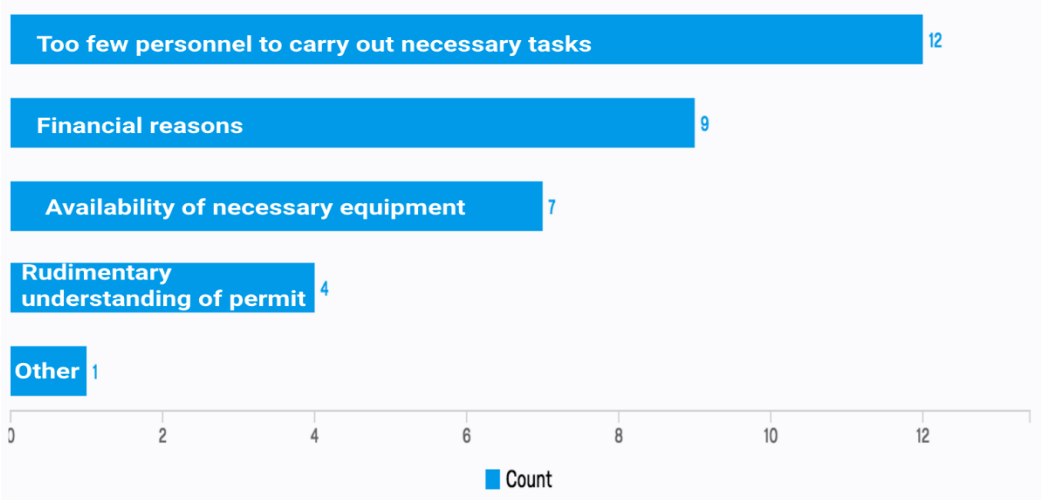

Figure 9: Obstacles with the 2016 MS4 permit compliance

During our interviews with Ms. Briggs and Frederick Civian, who both work for the MassDEP and have rich experience working with municipal officials about stormwater management, Mr. Civian explained to us why many central Massachusetts municipalities reached out for help or join forces with other municipalities to form a coalition in order to comply with the 2016 MS4 permit (personal communication, April 11, 2016). Municipalities need to share resources because it is difficult for town officials to convince residents to budget sufficient funds for MS4 requirements that residents may not recognize the importance of. Residents are more likely to support spending the town's budget on changes they can see such as a new fire engine rather than some underground pipes for the MS4s (F. Civian, personal communication, April 11, 2016). In addition, one requirement under the IDDE minimum control measure in the 2016 MS4 permit is to map all components of the MS4. This map must include: the location of all outfalls, the names of all waters that receive discharges from those outfalls, the

Figure 10: Example of a catch basin in the town of Holden

location of catch basins, the location of manholes, the location of pipes within the system, and some other various elements involved with MS4s (USEPA, 2016c). There are usually numerous catch basins, outfalls, and other components of the MS4s around towns and cities. To complete a map that will fully comply with the requirement, the municipalities need to put in a lot of manpower and time to do research and develop the map, but most municipalities do not have enough employees who are responsible for stormwater management.

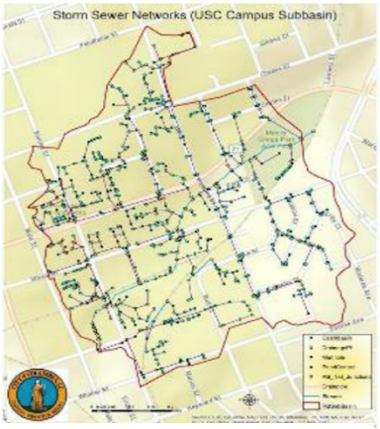

Figure 11: Examples of a map with locations of catch basins and manholes
(City of Columbia, 2013)

In addition to the communication with Ms. Briggs and Mr. Civian, the survey report also shows the challenges that towns are facing in a different way. In the survey for the Coalition members, we asked whether a town has a dedicated position for stormwater management, such as a stormwater coordinator, since most towns think meeting the requirements of the 2016 MS4 permit can be a complex process. Out of 12 respondents, 11 indicated they do not have a dedicated position for stormwater management (see Figure 12 below) largely due to having a limited budget. Overall, most central Massachusetts municipalities are seeking help getting more resources such as funding, manpower, and equipment.

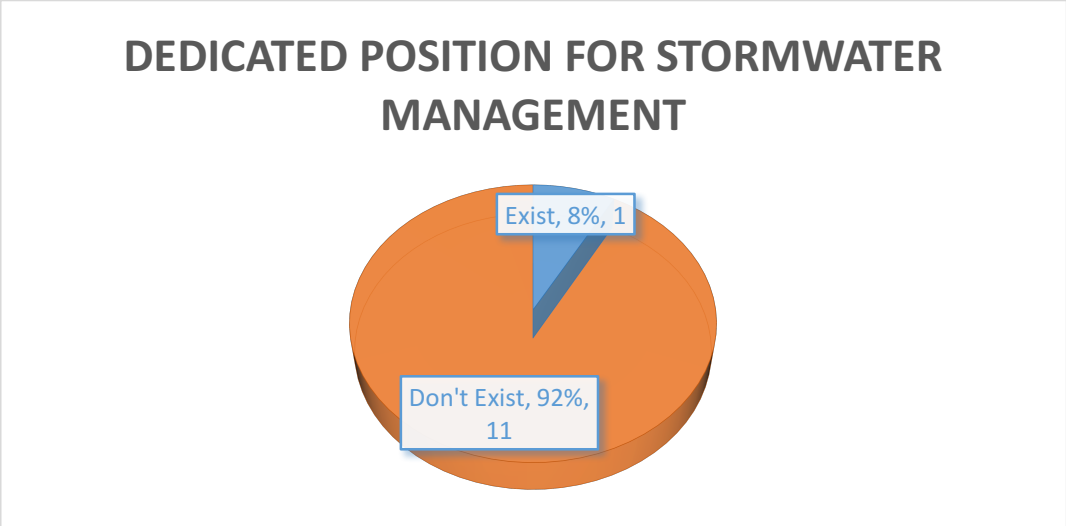

Figure 12: Percentage of Coalition member towns with a dedicated position for stormwater management

4.4 Resources for central Massachusetts municipalities

Limited resources are available to municipalities to comply with the 2016 MS4 permit. In this section, we discuss various materials that exist for central Massachusetts municipalities to help with this task.

Finding 6: There are many existing educational materials available for municipalities to help them comply with the *Public Education and Outreach* minimum control measure

Under the *Public Education and Outreach* minimum control measure in the 2016 MS4 permit, the municipalities are required to develop an educational program This program must include messages to the public about stormwater management, particularly, information about the impact of stormwater runoff and activities that the public can take to help eliminate stormwater pollution (USEPA 2016).

Mr. Tedder confirmed that the USEPA is developing educational materials for municipal officials to use. There are some materials that already exist that can be found through USEPA's website (personal communication, May 26, 2016). Also, during the interviews with directors of NEMO programs, the directors all mentioned that one of their priorities is to teach town officials

how to do public outreach through workshops. Organizations like NEMO and the Massachusetts Watershed Coalition *(MWC)* have and continue to develop educational materials and programs which can help towns fulfill the *Public Education and Outreach* minimum control measure.

On the MWC's website, there is a page named "BGY For Homeowners: DIY Stormwater Runoff Solutions" that targets homeowners and talks about what homeowners can do to help eliminate stormwater runoff, such as rain gardens, which help hold stormwater and let it seep into the ground. Furthermore, Connecticut NEMO developed a phone app to teach residents how to build a rain garden. Northland NEMO created a tool called "Watershed Game" that teaches students, teachers, and officials about stormwater runoff. Rhode Island also has a webpage that shares information about stormwater solutions (see Table 2). With all the interviews with different organizations that we have conducted during the project, we found that there are lots of existing educational materials are designed to comply with the *Public Education and Outreach* minimum control measure.

Organization	Existing Educational Material	Message
USEPA	Nonpoint Source (NPS) Outreach	Various resources to help develop an effective and targeted outreach campaign
Connecticut NEMO	Rain Garden App	Activities the public can take to help reduce stormwater runoff. Low Impact Development(LID)
Northland NEMO	The Watershed Game	The impact of stormwater runoff. Best Management Practices (BMPs)
Rhode Island NEMO	Stormwater Solution	Activities the public can take to help reduce stormwater runoff. Low Impact Development(LID)

Table 2: Existing materials for *Public Education and Outreach*

Finding 7: In-person workshops are the most efficient delivery method for educating town officials

Through our interviews with various stormwater experts and from the results of our survey, we determined the most efficient delivery method for educating town officials is through in-person workshops. According to Mr. Billota, adults like to "get their hands dirty" (personal communication, May 26, 2016) when learning. One method he claimed works well is to take municipal officials on bus tours, or out on boats to give the workshops, as it is easier to show the impact that stormwater management can have. Workshops allow for open forum discussions among members. When discussing the effectiveness of workshops, Lorraine Joubert, director of the Rhode Island NEMO program, said these open forum discussions are particularly effective, as they allow for municipal officials to discuss what works well for them in regards to stormwater management, and allows them to ask for advice or clarification in certain areas of the permit. In our survey, we asked respondents "What delivery method would you find most effective for learning some of the nuances of the MS4 permit?" six of the eleven respondents (55%) claimed that in-person workshops would be most effective (see Figure 13 below).

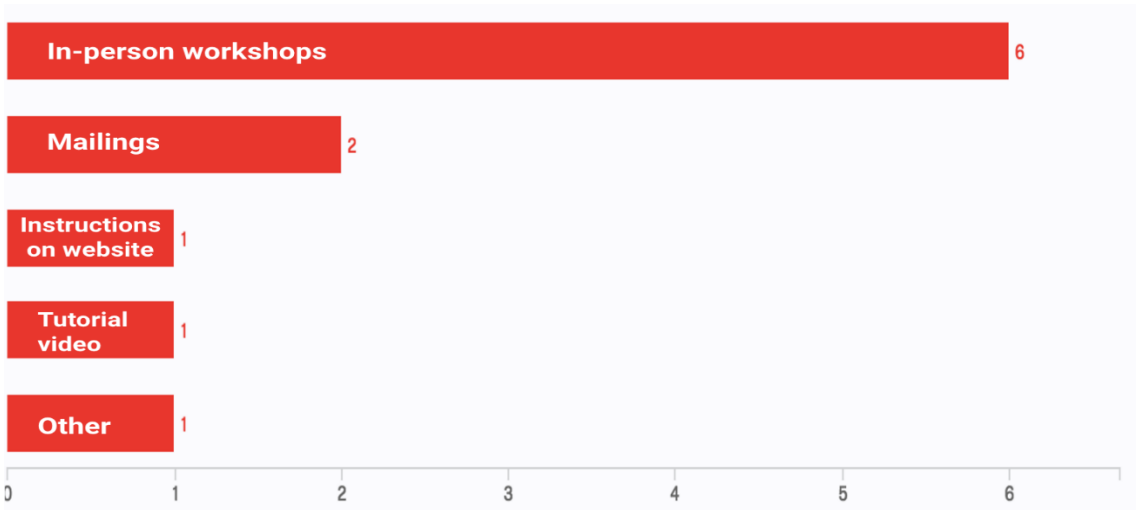

Figure 13. Results from Question 10 in "Survey for the CMRSWC Steering Committee"

Finding 8: Timelines, template language, and checklists provide the most assistance for central Massachusetts municipal officials to comply with the 2016 MS4 permit

To determine the best medium to present our permit compliance materials, we looked at our analysis of different types of educational materials and the data we collected from the survey and interviews. We found that timelines, template language, and checklists are three educational materials that would provide the most assistance for complying with the permit.

As detailed in Finding 5, towns often do not have enough personnel to create materials to comply with all the requirements in the 2016 MS4 permit. Based on her experience working with town officials, Ms. Briggs suggested that creating template language for requirements in the permit will be useful for town officials. Template language would allow town officials to comply with a given requirement without much time commitment (personal communication, April 11, 2016). The template language will help save municipalities time, personnel and money that might otherwise be spent to hire more people to comply with the requirement.

As mentioned in Finding 1, the 2016 MS4 permit has much more stringent requirements than the current 2003 MS4 permit, which is another reason why towns do not have enough personnel and time to comply with the permit. Ms. Briggs claimed, based on her own working experience and understanding about town officials, that town officials often like to have a checklist of simplified requirements because a checklist saves time and helps track the progress (personal communication, May 25, 2016).

While we were analyzing which educational materials that other states, including Connecticut, Minnesota, Rhode Island, and New Hampshire, had created to help their town officials, we interviewed the directors of different organizations who work on stormwater management. Michael Dietz, the director of Connecticut NEMO, found a timeline of requirements' due dates to be very useful for towns. Consequently, Mr. Dietz created one to match the

Connecticut MS4 permit (personal communication, May 19, 2016). Mr. Andrews, an employee of the NHDES, shared the same opinon and also developed timelines for New Hampshire municipalities (personal communication, May 26, 2016). Mr. Tedder, the drafter of the 2016 MS4 permit, agreed that checklists, templates and timelines can be helpful for town officials and are worth developing (personal communication, May 26, 2016).

The result from the survey for the Coalition members also support Mr. Tedder and Mr. Dietz's comments. In the survey, we asked town officials how the Coalition could provide them with more assistance in complying with the 2016 MS4 permit. Eight (8) of 10 respondents found template language and a list of requirements with due dates to be the two most helpful resources (see Figure 14).

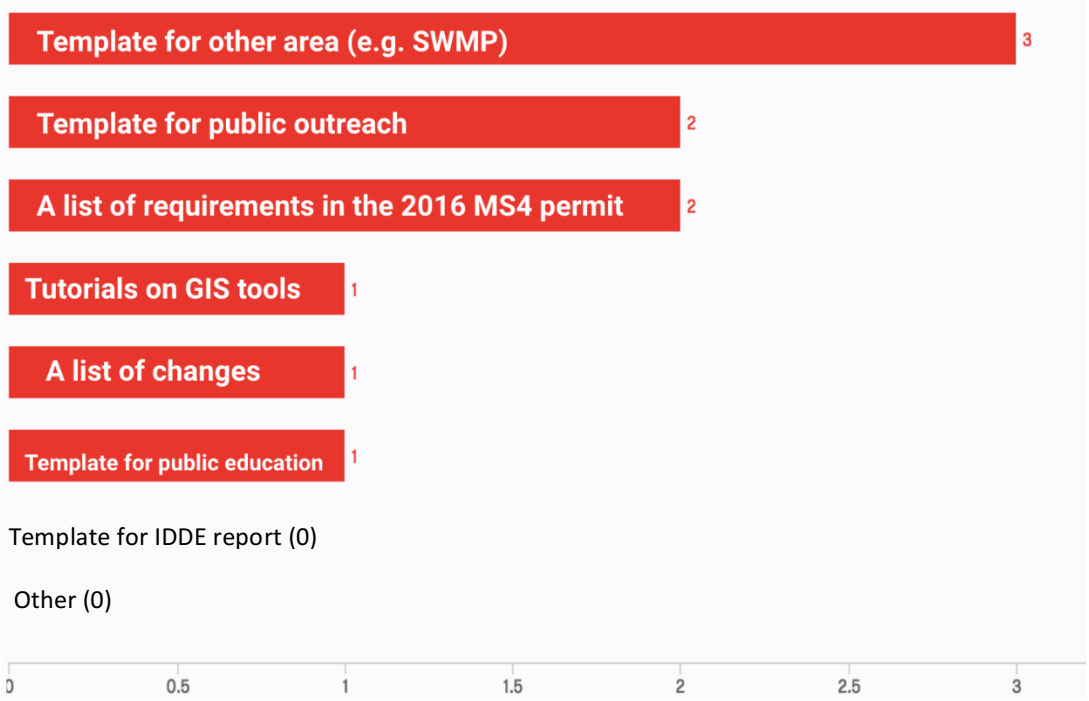

Figure 14: Results from Question 12 in "Survey for the CMRSWC Steering Committee"

5.0 Results and Recommendations

In the beginning of this chapter, section 5.1, we briefly introduce the results of our project. Next, we describe our recommendations for the *Central Massachusetts Regional Stormwater Coalition (CMRSWC, or the Coalition),* our co-sponsor, and central Massachusetts municipalities, our target audience for the step-by-step compliance documents. At the end of this chapter, we provide some recommendations to the *United States Environmental Protection Agency (USEPA)* in response to our findings of what municipalities find to be confusing in the *2016 Municipal Separate Storm Sewer System (MS4)* permit.

5.1 Project results

Using our project findings (see Table 3 for details), we created the MS4 Compliance Guideline for Massachusetts municipal officials to assist them with meeting the 2016 MS4 permit requirements, as well as an educational video for the town of Holden as part of their *Public Education and Outreach* program required by the MS4 permit.

	Pros	Cons
Checklist	• Can track progress • Easy to use • Presents permit requirements	• Not comprehensive
Timeline	• Shows when requirements must be completed by	• Information dense - difficult to digest
Step-by-step guideline	• Provides user with *how* to meet requirements	• Difficult to digest
Phone app	• Intuitive	• Time consuming to create • Requires user to have a smartphone
Tutorial video	• Easy to follow	• Time consuming to create

Table 3: Pros and Cons for different types of educational material

We made the Guideline to assist municipalities with the first, *public education and outreach*; second, *public involvement and participation*; and sixth, *good housekeeping* minimum control measures in the MS4 permit, along with the *Notice of Intent (NOI)* and *Stormwater Management Program (SWMP)*. For each of these permit sections, the Guideline contains timelines, checklists, and step-by-step instructions. (see Appendix E for MS4 Compliance Guideline).

The timelines and checklists present the various requirements for a given section of the permit in a much more cohesive and easy to understand manner. For example, we organized the timelines and checklists by whether the requirement is a one-time, annual, ongoing, or intermittent requirement. Whereas the permit lists requirements based on minimum control measure, this chronologic way of presenting a condensed version of the requirements may be clearer and quicker for overstretched municipal officials to interpret and implement. In Figure 15, below, is an excerpt of the checklist we developed for the sixth (6^{th}) minimum control measure. Our aim in doing this is to allow the municipality to focus their time and effort on meeting the permit requirements rather than trying to figure out what they are.

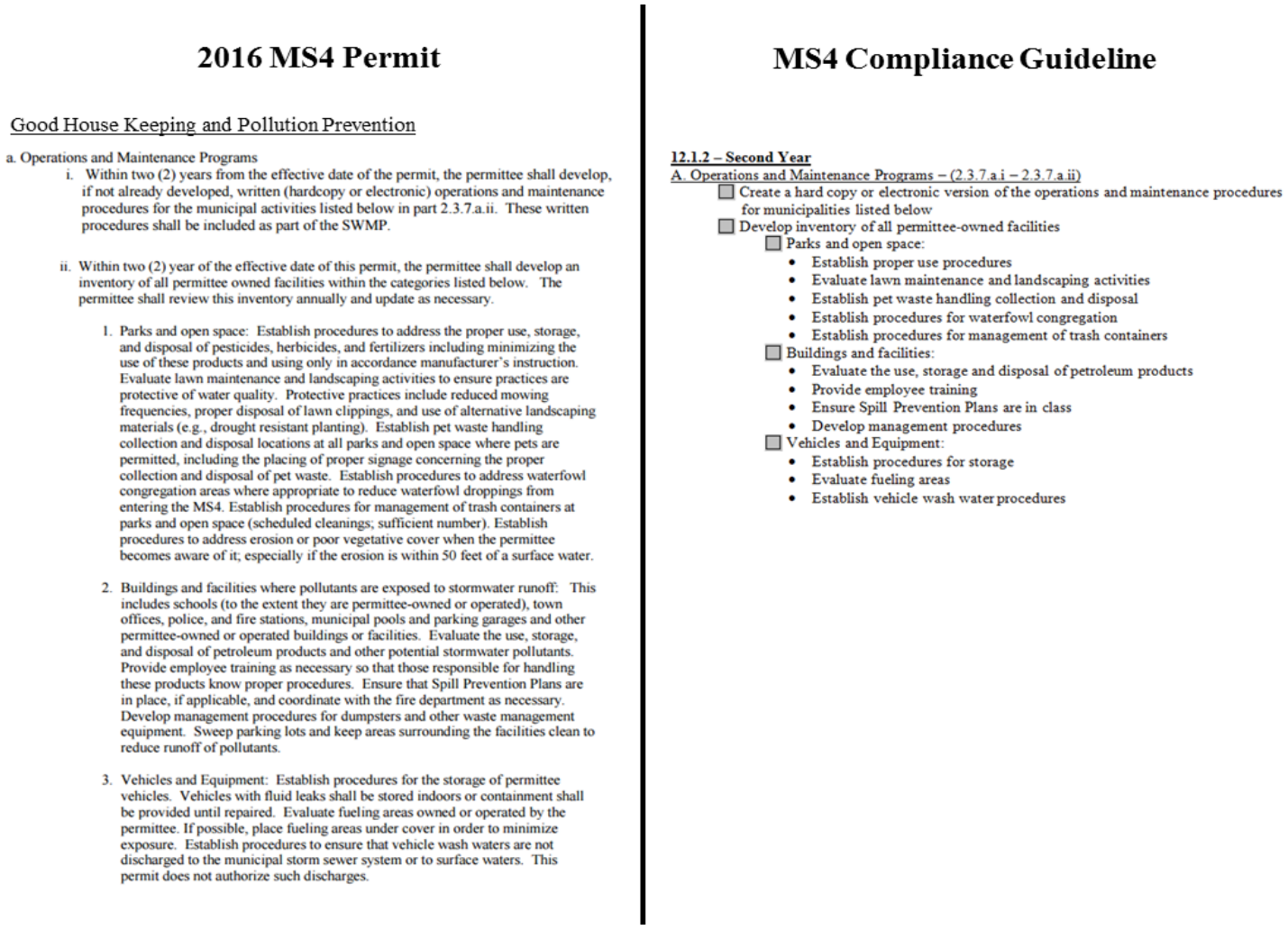

Figure 15: Comparison between actual permit and a checklist

The timelines included in the documents complement the checklists. They present the requirements, along with the times when they must be met by (see Appendix E: MS4 Compliance Guideline). This provides municipalities with an easy way to prioritize the various requirements, and to ensure that they meet the requirements in the time allotted by the USEPA.

Many of the requirements in the permit are not straightforward; they require the municipality to jump around to different sections and appendices of the permit in order to figure out what they need to do. For example, if a municipality's MS4 is subject to a TMDL in permit section 2.2.1 (*Discharges Subject to Requirements Related to an Approved TMDL*), they must

reference permit Appendix H for additional messages to include in their *Public Education and Outreach* program. However, no reference to this requirement is made in permit section 2.3.2 (*Public Education and Outreach*), where the *Public Education and Outreach* program is introduced. In order to help alleviate this problem, we developed step-by-step instructions for the permit. The aim was to make these instructions as straightforward for the municipality as possible. In practice, the municipality should be able to follow the procedures laid out in the instructions we developed in order to meet the various requirements, without the need to jump across various sections of the permit.

The video we developed for the town of Holden will be distributed by the town as one of the two messages they must distribute to residents under the *Public Education and Outreach* minimum control measure in the 2016 MS4 permit. The video is about five minutes long, and includes information for residents about stormwater runoff management, MS4 systems, and steps residents can take to help eliminate stormwater runoff pollution. To start the video, we show key locations in the town so the residents of Holden can understand how the video relates to them. For the next part of the video, we use a map to show all the outfalls, catch basins, and manholes around the town. We then highlight and show footage of a catch basin and outfall to show that stormwater runoff enters a catch basin and subsequently discharges from a connected outfall untreated. The map also shows main roads, rivers, ponds, and landmarks around town. We then focus on different water bodies around Holden that have been affected by water pollution, and show different techniques to prevent poor water quality that can be caused by stormwater runoff. At the end of the video, we include a few tips for the residents of Holden to help with mitigate stormwater pollution.

5.2 Recommendations for central Massachusetts municipalities

In Findings 5 (see Section 4.3 for details), we discussed the challenges that the municipalities are facing with the compliance of the 2016 MS4 permits. From our experience working with different organizations and interviews with experts, we developed the following recommendations for central Massachusetts municipalities to overcome the obstacles.

Individual towns and cities have limited resources so it can be very helpful to join a regional organization where everyone in the region is facing the same challenges, in this case, complying with the 2016 Massachusetts General MS4 permit. One of our sponsors, the CMRSWC, is an organization that facilitates collaboration among 31 central Massachusetts municipalities on stormwater management. The Coalition allows individual communities to pool resources together in order to help drive costs down. For instance, several towns and cities can share one piece of equipment needed to screen outfalls for the *IDDE* minimum control measure, and therefore can also share the cost of the equipment.

In addition, municipalities need to keep in mind that the 2016 MS4 permit has much more stringent requirements. Municipalities need to start developing and implementing a plan and allocating resources early on so they are prepared for the effective date of the permit, July 1, 2017. It is important to prepare early because some requirements in the permit have a relatively early deadline. For example, a permittee must submit a NOI within 90 days after the effective date (by September 29th, 2017), otherwise stormwater discharges into surface water are not allowed.

To help prepare early, **our recommendation is to attend workshops or review materials from the workshops held by the *Massachusetts Department of Environmental Protection (MassDEP)* and the USEPA**. In May and June, 2016, there were five workshops held for different regions of Massachusetts. They covered various the deadlines of the MS4 permit, and go over

major changes between the 2003 and 2016 Massachusetts MS4 permits. The workshops are a good place for town officials to gain a solid understanding of the requirements in the 2016 permit and ask any questions they may have face-to-face. Another recommendation is that **municipalities do not need to reinvent the wheel; rather they should use the existing materials and tailor them to their individual needs** (see Appendix G for links to existing materials). Also, the documents that our team has created, which will be published on the CMRSWC website, WCPC website and WROC website, are helpful tools that can assist a municipality with permit compliance (see section 5.1 for detail description of the documents and Appendix E for actual material).

5.3 Recommendations for the CMRSWC

According to Findings 5, 7 and 8, **we recommended that the Coalition try to hold more in-person workshops since most of the Coalition members found this delivery method to be most helpful.** For the topics of the workshops, most of the Coalition members were most concerned about the *Geographic Information System (GIS)* mapping, *Illicit Discharge Detection and Elimination (IDDE)* minimum control measure, and *Total Maximum Daily Loads (TMDLs)* and *Water Quality Impaired Waters* requirements (see section 4.3 and 4.4 for details). In order to quickly develop the workshop, **the Coalition should look into existing workshops and educational materials** developed by other organizations such as the *Nonpoint Education for Municipal Officials (NEMO)* programs, the MassDEP, the USEPA, and the Massachusetts Watershed Coalition *(MWC)* (see Appendix G for links to useful resources).

In addition to workshops, **the Coalition should create more checklists, template language, and timelines for the requirements in the permit.** Consequently, we recommend that the Coalition reach out to Worcester Polytechnic Institute's Water Resource Outreach Coalition

(WROC), seeking an additional student project to help with development of additional educational materials, or workshop development (see Appendix G for contacts for useful resources).

5.4 Recommendations for the USEPA

Most of the comments from the municipalities on the 2016 MS4 permit are about the ambiguous terms in the permit. **We recommend that the USEPA include more guidance to clarify the meaning behind potentially ambiguous language**. We think it will be easier for municipal officials to understand and comply with the permit if the USEPA can give more guidance such as examples and links to useful resources.

6.0 Conclusion

In collaboration with the *Massachusetts Department of Environmental Protection*, the *Central Massachusetts Regional Stormwater Coalition*, and the town of Holden, we were tasked with developing educational materials to help central Massachusetts municipalities comply with the 2016 Massachusetts General *Municipal Separate Storm Sewer System (MS4)* permit, which is more stringent than the current 2003 MS4 permit. We analyzed the obstacles central Massachusetts municipalities are facing and which parts of the permit they are most concerned about. Next, we looked over what organizations in other states did to help their municipal officials improve stormwater management and what educational materials or methods they found to be most helpful. Also, we asked our target audience, central Massachusetts municipal officials in charge of stormwater management, what they believe to be helpful tools.

With all the information from interviews, meetings and the survey, and given our project's time frame, we concluded that a document called MS4 Compliance Guideline—with checklists, timelines, and step-by-step instructions for the first, second, and sixth minimum control measures in the 2016 MS4 permit—is the most useful educational material for central Massachusetts municipalities. We subsequently developed these materials for the Coalition and member municipalities. The Guideline can help municipal officials save time, money and manpower spent on complying with the permit since it makes the permit easier to understand and gives municipal officials an instruction on how to meet the requirements in the permit.

Overall, we believe that using the Guideline that our team developed will make compliance of the 2016 MS4 permit easier for central Massachusetts municipalities. In turn, we hope increased compliance with the permit will help improve and protect surface water quality in central Massachusetts.

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Appendix A: Sponsor information

The *Central Massachusetts Regional Stormwater Coalition (CMRSWC)* (2016f) is a coalition of towns in the central Massachusetts area that work together to address municipal stormwater management. The CMRSWC was originally formed by a group of 13 communities, including Auburn, Charlton, Dudley, Holden, Leicester, Millbury, Oxford, Paxton, Shrewsbury, Spencer, Sturbridge, Webster, and West Boylston. Since its founding, 17 new communities have been added. This second group includes Boylston, Grafton, Hardwick, Hopkinton, Monson, Northbridge, Northborough, North Brookfield, Palmer, Rutland, Southbridge, Sterling, Upton, Uxbridge, Ware, Westborough, and Wilbraham.

The CMRSWC (2016a) aims to tackle the problems of stormwater management for the communities involved. These communities must comply with the stormwater management regulations laid out in the MS4 permit issued by the *United States Environmental Protection Agency (USEPA)*. Rather than having each town set aside resources to overcome this problem, the CMRSWC was formed to help create standards for stormwater management for all involved communities to use. In addition, the CMRSWC provides tools and a framework to help each town implement and maintain an effective stormwater management system.

The CMRSWC (2016a) is funded by a Community Innovation Challenge Grant from the Massachusetts Executive Office of Administration and Finance. The coalition works with Tata & Howard, Inc., and Verdant Water for stormwater consulting (CMRSWC, 2016c). Maine Technical Source, HACH Company and Chemetrics provide survey and water quality equipment for CMRSWC. Some other project partners include the *Massachusetts Department of Environmental Protection (MassDEP)*, Massachusetts Department of Conservation and Recreation, Central Massachusetts Regional Planning Commission, PeopleGIS, and Worcester Polytechnic Institute.

The lead organizations of the coalition are the Town of Spencer and the Town of Charlton (Massachusetts Stormwater Coalition, 2015, p.1). The coalition is part of the Massachusetts Statewide Stormwater Coalition, a larger coalition made up of the CMRSWC and four other stormwater management groups in Massachusetts (CMRSWC, 2016b).

The CMRSWC (2016d) has professional equipment for water quality testing. The CMRSWC (2016e) also developed an educational website to educate residents, municipal officials, contractors, and others about the stormwater pollution. The organization's communities share stormwater systems and surface water resources. The CMRSWC developed an online database to allow all the members to share information. The organization has also used their technology to build a mapping system called Stormwater System Mapping Integration, which helps show the MS4 areas in each community. The CMRSWC brings the communities that are facing the same water pollution problems together. By using new technologies and sharing information, the CMRSWC gathers all the necessary information to help communities adapt new MS4s permit and solving stormwater pollution.

The MassDEP, the other project sponsor, is the state agency responsible for maintaining a clean and safe environment (Mass.Gov, 2016a). The department is headquartered in Boston, with additional offices in Wilmington, Springfield, Worcester, Lakeville, and Lawrence (2016b). The current commissioner, Martin Suuberg, was appointed on January 8, 2015 by the Secretary of Energy & Environmental Affairs (2016c). He oversees various department managers of the organization. Of note is the Operations and Environmental Compliance Department. This department is responsible for permitting, compliance, and enforcement of the policy. We will be working closely with this department throughout the project.

Appendix B: Sample interview protocol

Interviewee: Michael Dietz, Director of Connecticut Nonpoint Education for Municipal Officials
Interviewer: Geneva Cabral, Zixin Luo, Nicholas Rowles

Introduction:

We are students from Worcester Polytechnic Institute completing a research project with the *Massachusetts Department of Environmental Protection*, the *Central Massachusetts Regional Stormwater Coalition*, and the town of Holden. We are assisting central Massachusetts municipalities in complying with the recently issued 2016 Massachusetts MS4 permit by developing educational materials for them. We found that the *Nonpoint Education for Municipal Officials (NEMO)* program is doing an outstanding job of providing municipal officials with assistance on stormwater management, so we want to learn from your experience on educating town officials

Topics Discussed:

- Interviewee background:
    - How did you first get involved with NEMO? What is your role as the director? Do you get out and give workshops, or do you take on more of a managerial role?
    - Do you have any experience in dealing with, or educating officials about the MS4 permit (CT or otherwise)?
- About NEMO program:
    - What municipal officials do you typically target (DPW, Conservation, etc.)? What are the most effective ways to educate them when it comes to stormwater management?
    - What resources does CT NEMO have? (funding, man force, collaborations such as URI)?
- Experience on educating town officials
    - In running workshops, what are some methods and tricks you use to keep your audience engaged?
    - What is the biggest impact that your workshops and programs have on your audience?
    - How do you determine what content to include when going to different municipalities? Do you start with a general template and tweak it as needed, or do you base the material around a particular town's needs?
    - How do you connect with town residents, and how do you gear your materials towards them?
    - How do you determine effectiveness of workshops and get feedback?
- Suggestions
    - What are some messages you want to send to the public in regards to protecting water resources, especially eliminating stormwater runoff?
    - Do you know of any other organizations that have worked with municipalities to increase their compliance with the most recent permit?

Appendix C: Survey for the CMRSWC steering committee

Survey for the Central Massachusetts Regional Stormwater Coalition Steering Committee

This survey should take less than 5 minutes.

We are a group of students from Worcester Polytechnic Institute's Worcester Community Project Center working with the *Massachusetts Department of Environmental Protection (MassDEP)*, the *Central Massachusetts Regional Stormwater Coalition* (CMRSWC or the Coalition), and the town of Holden to create educational materials to help central Massachusetts municipalities comply with the 2016 MS4 permit. We will be using the information from this survey to develop materials that are most useful to central Massachusetts municipalities. Please let us know if you would like us to keep your identity confidential, or if you are comfortable with us using your name in our final project report. If you would like, we are happy to provide you with a copy of our results at the end of the study. Thank you for taking the time to complete this survey.

1. What town or organization do you work for?

_____

2. What is your position within the town or organization?

_____

3. Are you responsible for stormwater management within your town?
   - Yes
   - No

4. Does your town have a dedicated position for stormwater management?
   - Yes
   - No - please specify who takes on this responsibility: _____

5. If you answered 'Yes' to question 4, do you think having the dedicated stormwater management position makes it easier for your town to comply with the new 2016 MS4 permit.
   - Yes
   - No

Please describe why:

_____
_____

6. Have you used any resources to help you understand the 2016 MS4 General permit and its requirements. Please check all that apply.
   - The 2016 Massachusetts Small MS4 General Permit
   - CMRSWC website http://www.centralmastormwater.org/Pages/index
   - Massachusetts Watershed Coalition website http://www.commonwaters.org/
   - Massachusetts Department of Environmental Protection stormwater handbook
   - EPA educational materials https://cfpub.epa.gov/npstbx/index.html.
   - Other (please list below)

_____
_____
_____

7. Are you concerned about your ability to comply with the following control measures from the new 2016 MS4 general permit? Please check all that apply.

Minimum Control Measures	Not concerned	Somewhat concerned	Most concerned (only check one in this column)	I don't know
Public Education and Outreach				
Public Involvement and participation				
Illicit Discharge Detection and Elimination (IDDE) Program				
Construction Site Stormwater Runoff Control				
Post Constructive Stormwater Management				
Good Housekeeping and Pollution Prevention				

8. For the control measures that you are *most concerned* about, please share *why* you are concerned. Please check all that apply.

- Financial reasons
- Availability of necessary equipment
- Too few personnel to carry out necessary tasks (i.e. mapping all outfalls, and catch basins)
- Rudimentary understanding of the permit
- Other: please be specific

_____
_____

9. In what areas is the coalition currently offering the most assistance? Please check all that apply.

- Public Education and Outreach
- Public Involvement and participation
- *Illicit Discharge Detection and Elimination (IDDE)* Program
- Construction Site Stormwater Runoff Control
- Stormwater Management in New Development and Redevelopment (Post Constructive Stormwater Management)
- Good Housekeeping and Pollution Prevention for Municipality Owned Operations
- Stormwater Management Program (SWMP)
- Notice of Intent (NOI)

10. How might the Coalition provide more assistance?

- Providing templates for public education
- Providing templates for public outreach
- Providing templates for IDDE report
- Providing templates for other areas. Please be specific:

  _____

  _____

- Providing a list of requirements in the 2016 MS4 permit
- Providing a list of changes between the 2003 and 2016 MS4 permits
- Tutorials on how to use *Geographic Information System (GIS)* tools
- Other: please be specific

  _____

  _____

11. What delivery methods would you find most effective for learning some of the nuances of the MS4 permit?

- In-person workshops (at your town hall)
- Mailings (pamphlets, informational documents, etc.)
- Step-by-step MS4 compliance instructions on Website
- Tutorial video
- Other: _____

12. If we developed a tutorial video for residents/businesses/developers/industrial facilities on stormwater runoff. What topics would you find most useful? Please check all that apply:

- Impact of stormwater runoff
- Activities that will help reduce stormwater pollution with specific examples
- Information on how to get involved in stormwater management
- Introduction to MS4s and how they operate
- Information on current existing coalitions or programs
- Other: _____

13. Does your town currently have a plan to meet all of the 2016 MS4 permit requirements by the effective date (July 1, 2017)?

- Yes
- No
- I don't know

14. What do you think can be improved in the future surveys?
    1. Explain more on the MS4 language
    2. Add more multi-choice questions
    3. Add more fixed answers
    4. Explain more on the fixed answers
    5. Add more topics. Please be specific:

       _____
       _____

    A. Others. Please be specific:

       _____
       _____

15. Do you have any additional comments?

_____
_____

16. Is it okay if we use your name title(s) in our report?
    - Yes - Please provide your name below:

      _____
    - No

17. Would it be okay for us to follow up with if we have additional questions?
    1. Yes - Please provide your contact information below:

       _____
    2. No

Please feel free to contact us if you have any questions or comments. We can be reached collectively at WCCEERe16-students@wpi.edu

Thank you very much for taking the time to complete this survey.

Geneva Cabral, Zixin Luo, Nicholas Rowles

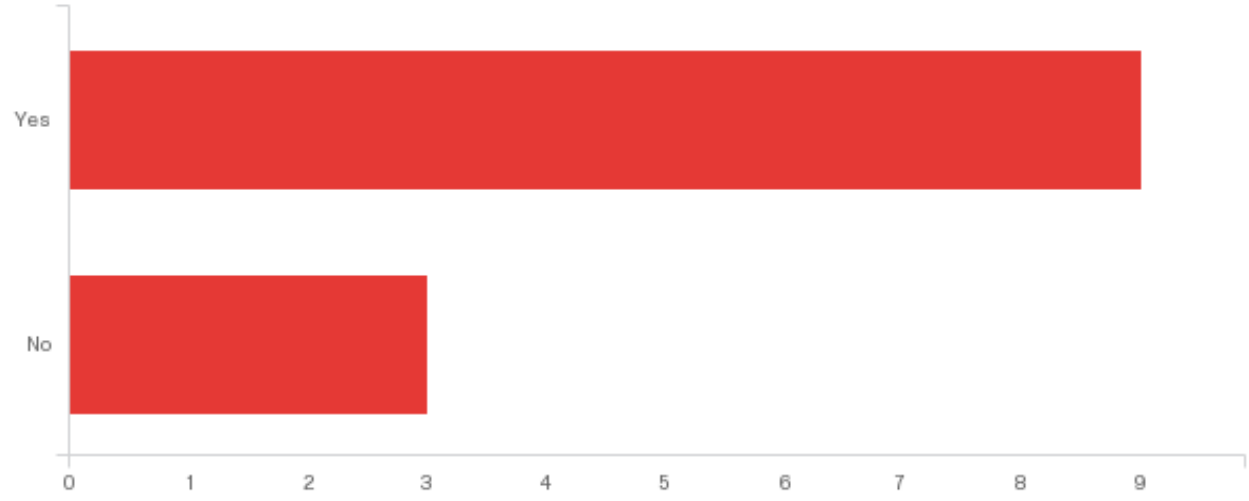
Appendix D: Survey report

This is the report for the survey in Appendix C. Questions involved with respondents' identity has been removed

Q3 - 2. What is your position within the town or organization?

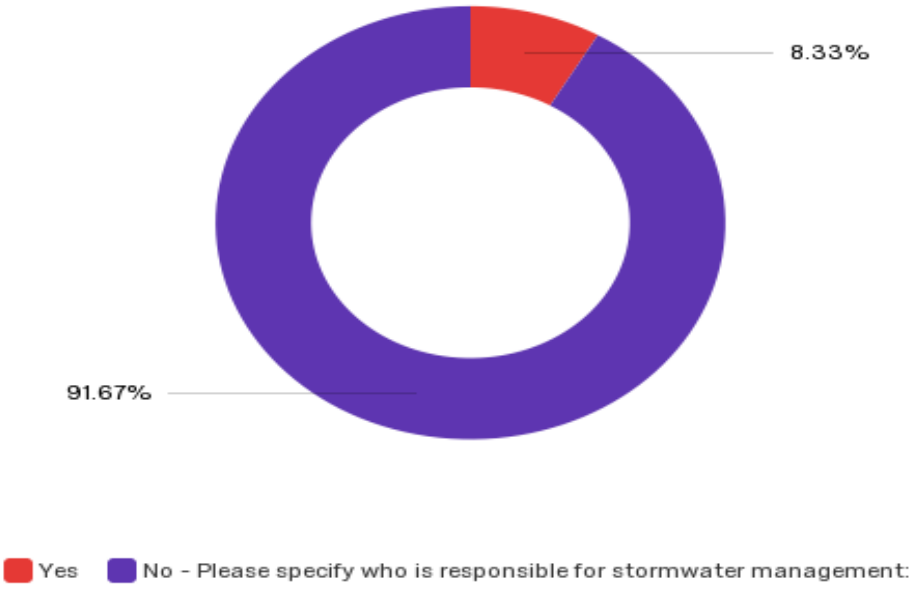
Engineer & Conservation Agent
Director Public Works
Conservation Agent
DPW Superintendent
Highway Superintendent
Sr. Civil Engineer
Conservation Agent
Member Board of Selectmen, Chair, Stormwater Task Force
DPW Director
Senior Stormwater Engineer
DPW Director
Deputy Regional Director

Q5 - 3. Are you responsible for stormwater management within your town?



Answer	%	Count
Yes	75.00%	9
No	25.00%	3
Total	100%	12

Q6 - 4. Does your town have a dedicated position for stormwater management?

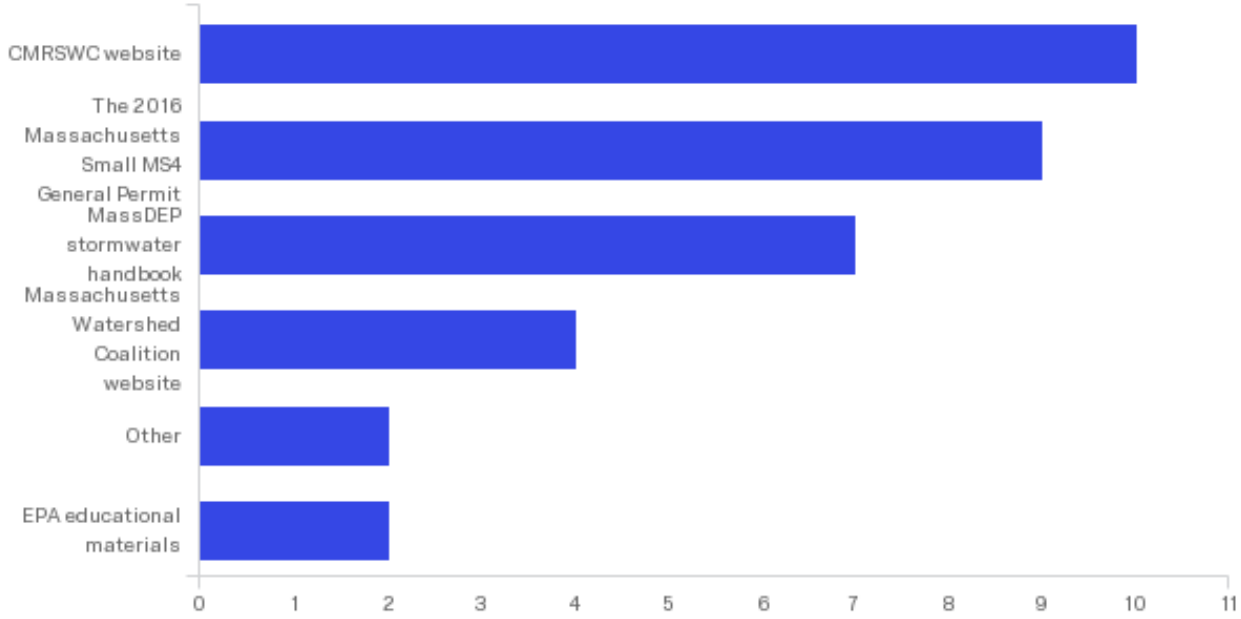


Answer	%	Count
Yes	8.33%	1
No - Please specify who is responsible for stormwater management:	91.67%	11
Total	100%	12

No - Please specify who is responsible for stormwater management:
me
Mix DPW/Con Com
DPW Superintendent

Highway Superintendent
DPW
Town Administrator/ Dept of Public Works
DPW DIRECTOR
DPW & Asst. DPW Director
DPW Director

Q8 - 5. Have you used any resources to help you understand the 2016 MS4 General permit and its requirements Please check all that apply.

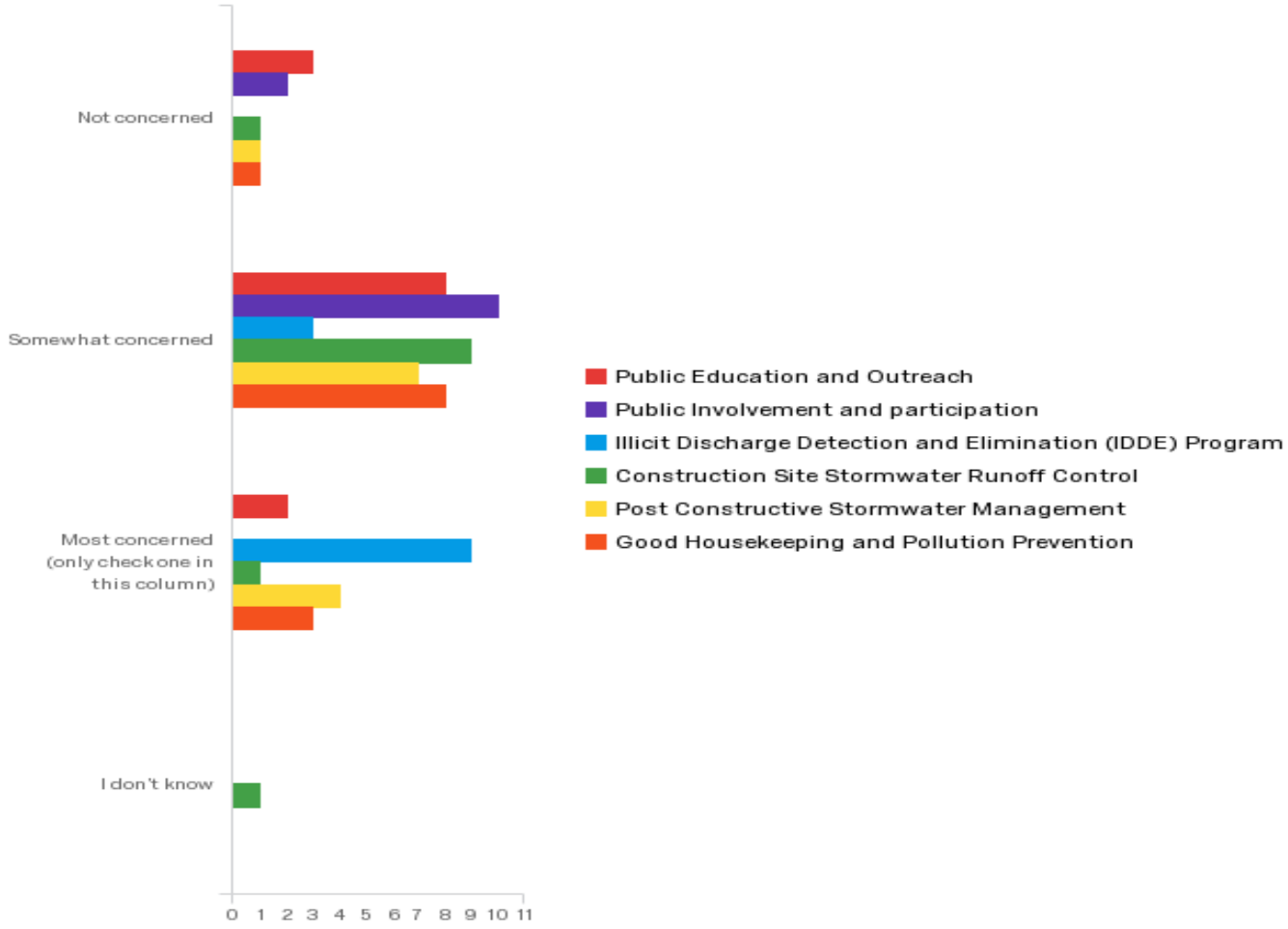


Answer	%	Count
The 2016 Massachusetts Small MS4 General Permit	75.00%	9
CMRSWC website http://www.centralmastormwater.org/Pages/index	83.33%	10
Massachusetts Watershed Coalition website http://www.commonwaters.org/	33.33%	4
Massachusetts Department of Environmental Protection stormwater handbook	58.33%	7
EPA educational materials https://cfpub.epa.gov/npstbx/index.html.	16.67%	2
Other. Please list below:	16.67%	2

Other. Please list below:

Other. Please list below:
Tata & Howard
Professional organizations & summary sheets from consulting firms

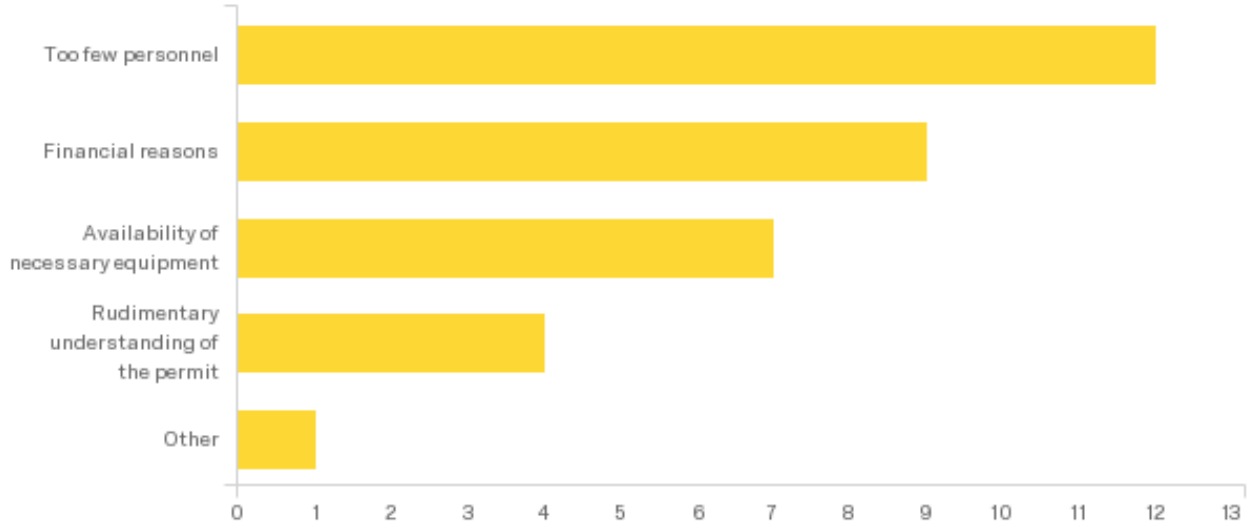
Q9 - 6. Are you concerned about your ability to comply with the following control measures from the new 2016 MS4 general permit? Please check all that apply.



Question	Not concerned		Somewhat concerned		Most concerned (only check one in this column)		I don't know		Total
Public Education and Outreach	23.08%	3	61.54%	8	15.38%	2	0.00%	0	13

Public Involvement and participation	16.67%	2	83.33%	10	0.00%	0	0.00%	0	12
Illicit Discharge Detection and Elimination (IDDE) Program	0.00%	0	25.00%	3	75.00%	9	0.00%	0	12
Construction Site Stormwater Runoff Control	8.33%	1	75.00%	9	8.33%	1	8.33%	1	12
Post Constructive Stormwater Management	8.33%	1	58.33%	7	33.33%	4	0.00%	0	12
Good Housekeeping and Pollution Prevention	8.33%	1	66.67%	8	25.00%	3	0.00%	0	12

Q10 - 7. For the control measures that you are most concerned about, please share why you are concerned. Please check all that apply.



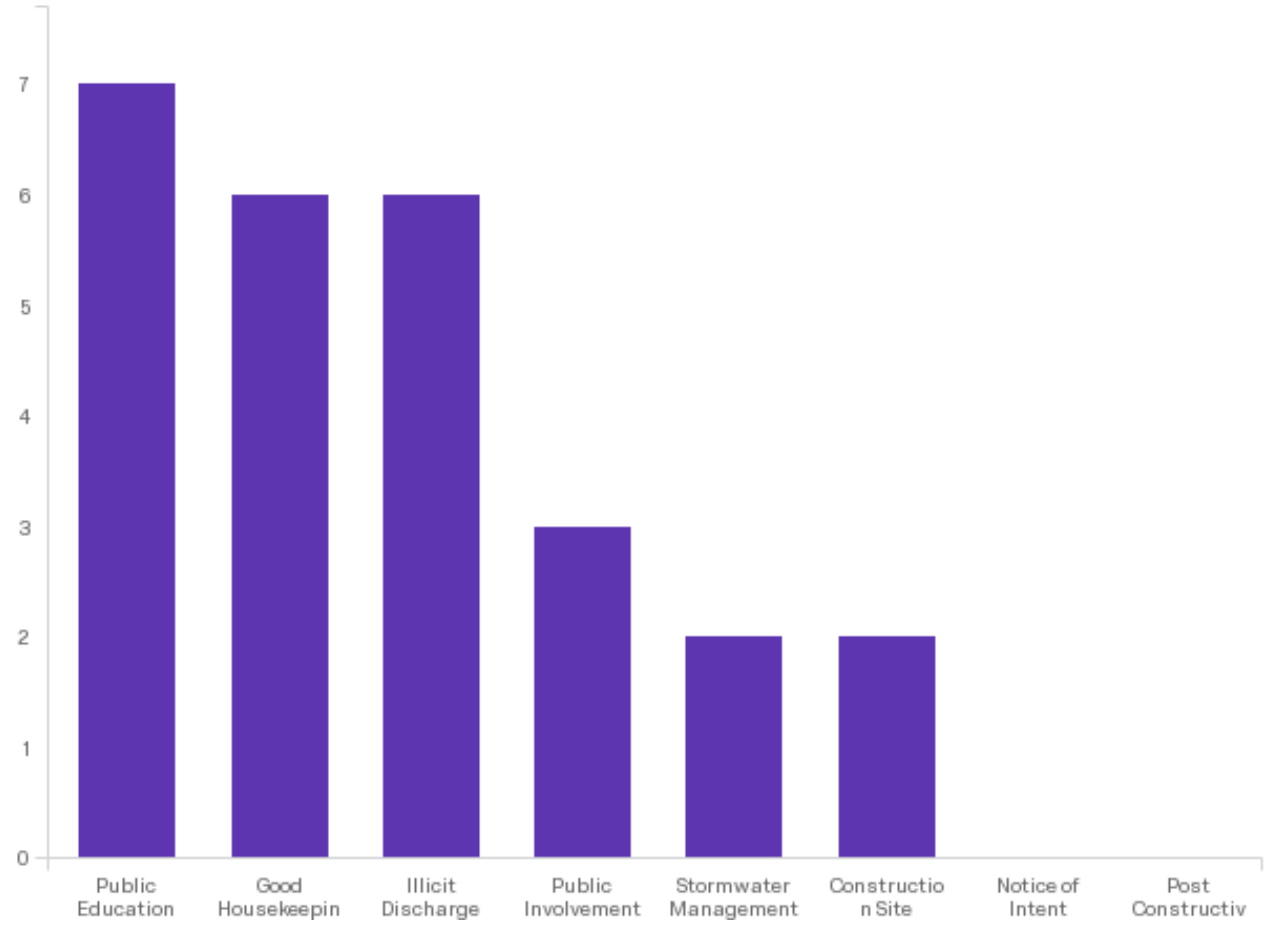
Answer	%	Count
Financial reasons	69.23%	9
Availability of necessary equipment	53.85%	7
Too few personnel to carry out necessary tasks (i.e. mapping all outfalls, and catch basins)	92.31%	12

Rudimentary understanding of the permit	30.77%	4
Other. Please be specific:	7.69%	1

Other. Please be specific:

Other. Please be specific:
Requires bylaw change (needs local leadership support, but its very technical)

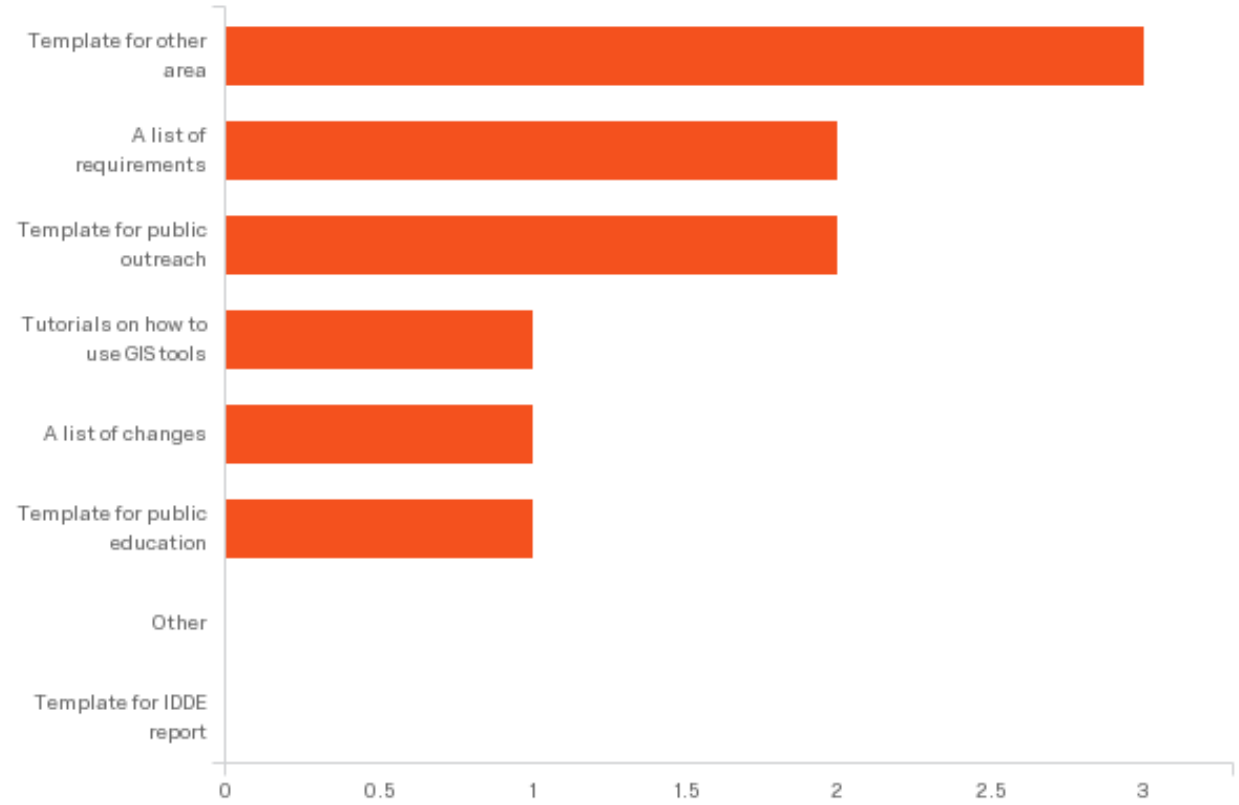
Q11 - 8. In what areas is the coalition currently offering the most assistance? Please check all that apply.



Answer	%	Count
Public Education and Outreach	63.64%	7
Public Involvement and participation	27.27%	3

Illicit Discharge Detection and Elimination (IDDE) Program	54.55%	6
Construction Site Stormwater Runoff Control	18.18%	2
Stormwater Management in New Development and Redevelopment (Post Constructive Stormwater Management)	0.00%	0
Good Housekeeping and Pollution Prevention for Municipality Owned Operations	54.55%	6
Stormwater Management Program (SWMP)	18.18%	2
Notice of Intent (NOI)	0.00%	0

Q12 - 9. How might the Coalition provide more assistance?



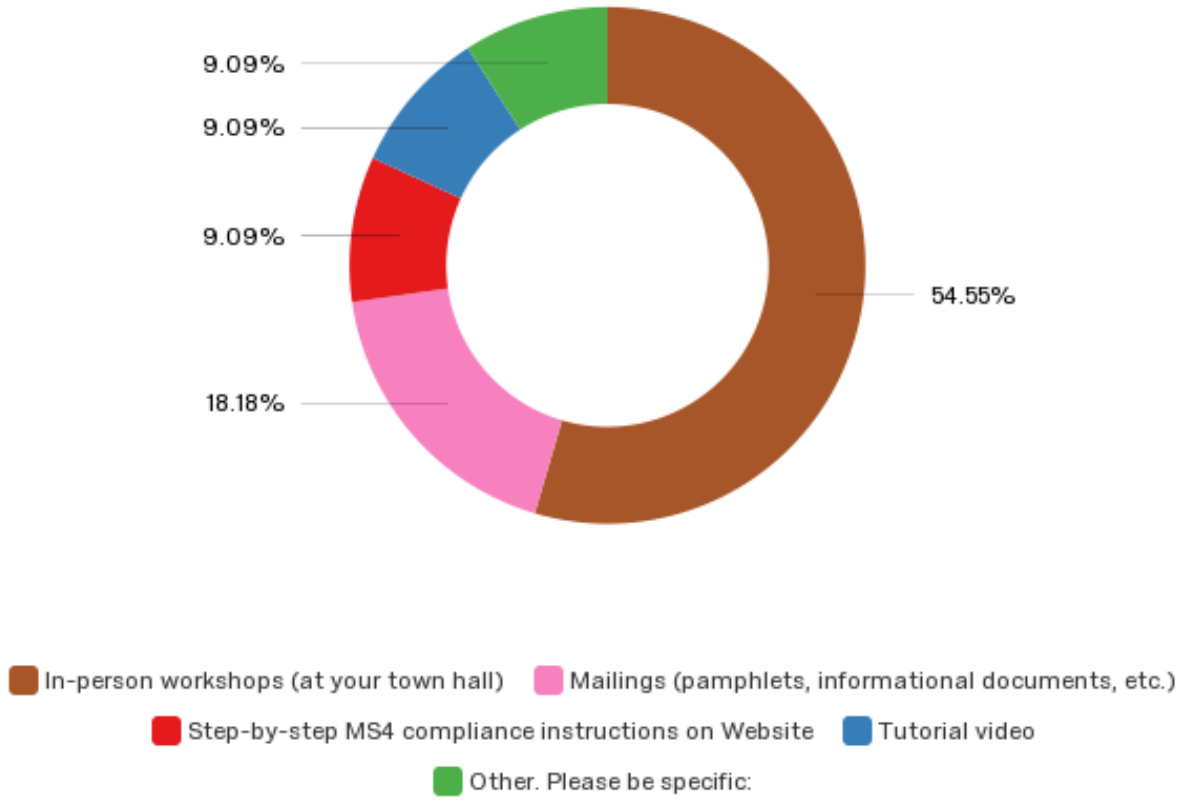
Answer	%	Count
Providing template for public education	10.00%	1
Providing template for public outreach	20.00%	2
Providing template for IDDE report	0.00%	0
Providing template for other area. please be specific:	30.00%	3
Providing a list of requirements in the 2016 MS4 permit	20.00%	2

Providing a list of changes between the 2003 and 2016 MS4 permits	10.00%	1
Tutorials on how to use *Geographic Information System (GIS)* tools	10.00%	1
Other. Please be specific:	0.00%	0
Total	100%	10

Providing template for other area. please be specific:

Providing template for other area. please be specific:
Stormwater Management Plan
Written construction & post-construction inspection procedures, draft stormwater regulations

Q13 - 10. What delivery methods would you find most effective for learning some of the nuances of the MS4 permit?



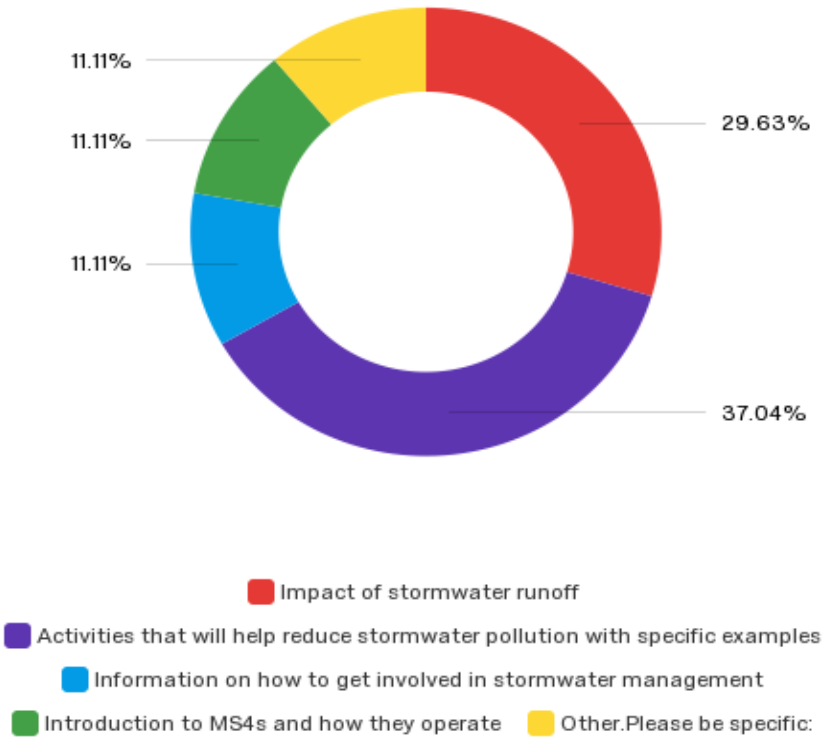
Answer	%	Count
In-person workshops (at your town hall)	54.55%	6
Mailings (pamphlets, informational documents, etc.)	18.18%	2

Step-by-step MS4 compliance instructions on Website	9.09%	1
Tutorial video	9.09%	1
Other. Please be specific:	9.09%	1
Total	100%	11

Other. Please be specific:

Other. Please be specific:
small regional workshops detailing the requirements for compliance and the resources available to help us.

Q14 - 11. If we developed a tutorial video for residents/businesses/developers/industrial facilities on stormwater runoff. What topics would you find most useful? Please check all that apply:



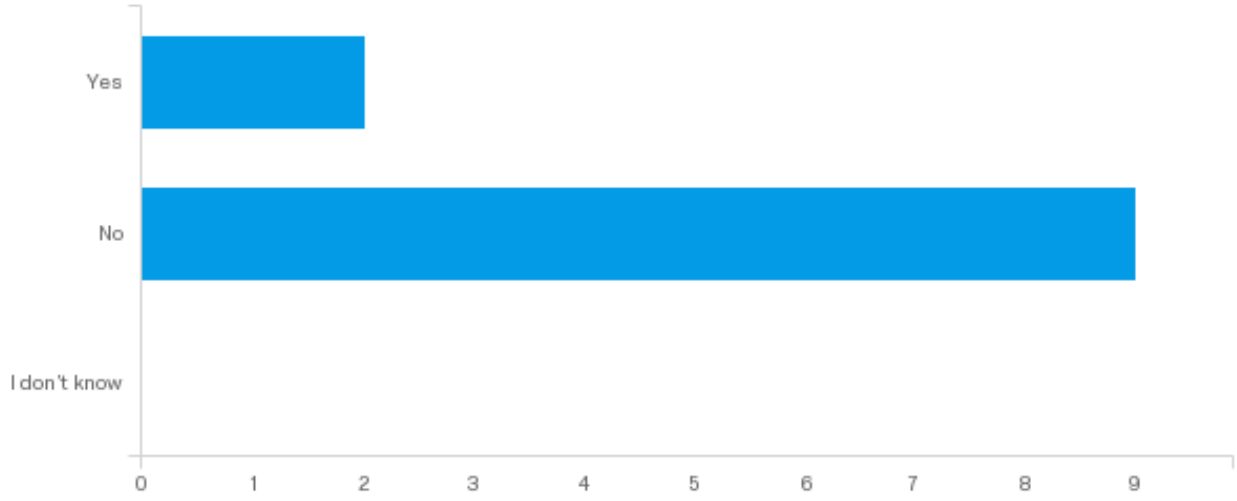
Answer	%	Count
Impact of stormwater runoff	72.73%	8
Activities that will help reduce stormwater pollution with specific examples	90.91%	10
Information on how to get involved in stormwater management	27.27%	3

Introduction to MS4s and how they operate	27.27%	3
Other. Please be specific:	27.27%	3

Other. Please be specific:

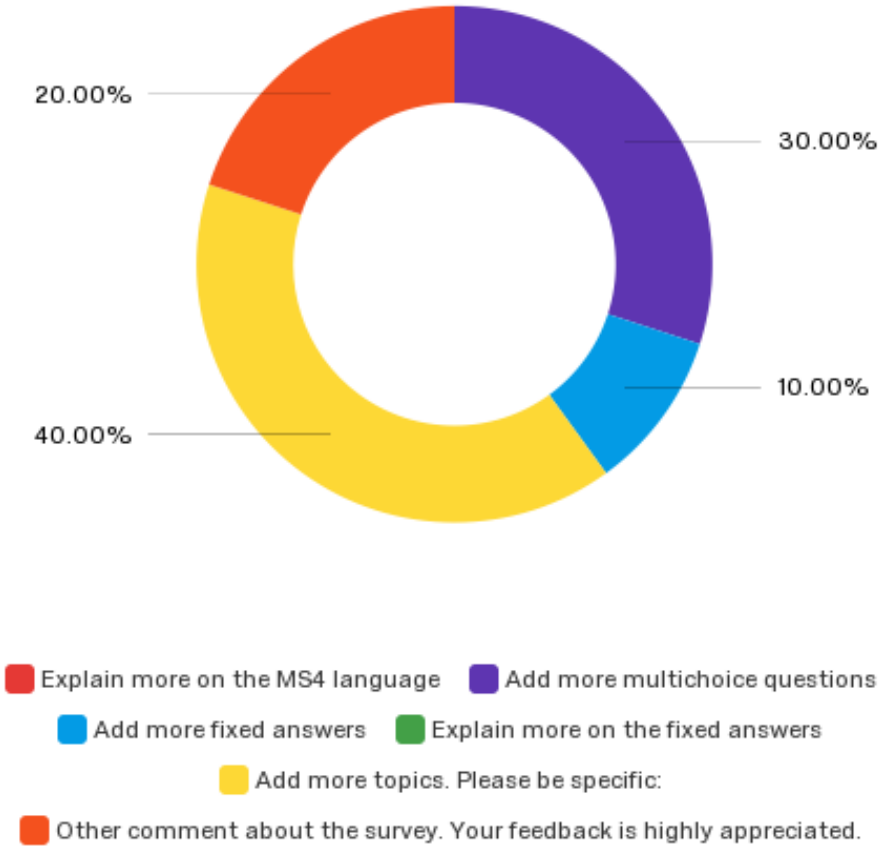
Other. Please be specific:
$ Impacts
What stormwater is, why it matters.
How the stormwater system is connected. (i.e. what happens to runoff once it goes down the storm drain); simple O&M practices

Q15 - 12. Does your town currently have a plan to meet all of the 2016 MS4 permit requirements by the effective date (July 1, 2017)?



Answer	%	Count
Yes	18.18%	2
No	81.82%	9
I don't know	0.00%	0
Total	100%	11

Q17 - 13. What do you think can be improved in the future surveys?



Answer	%	Count
Explain more on the MS4 language	0.00%	0
Add more multi-choice questions	37.50%	3
Add more fixed answers	12.50%	1
Explain more on the fixed answers	0.00%	0
Add more topics. Please be specific:	50.00%	4
Other comment about the survey. Your feedback is highly appreciated.	25.00%	2

Add more topics. Please be specific: additional comment boxes; see #14 comments.

Appendix E: MS4 Compliance Guideline

To help municipalities meet the requirements in the 2016 MS4 permit, we have created the *2016 MS4 Compliance Guideline*. The Guideline includes an overall timeline for the permit. Each requirement included in the timeline is covered later in the Guideline by a more comprehensive checklist. For each item in the checklist, there is a step-by-step instruction to assist in meeting that requirement.

The Guideline can be found at Worcester Polytechnic Institute's Worcester Community Project Center website:
http://wp.wpi.edu/wcpc/projects/projects-by-term/summer-2016/stormwater-management-educational-materials/

Appendix F: Educational video making procedure

This document details the process of making a stormwater focused educational video that can be used to comply with *Public Education and Outreach* minimum control measure in the 2016 Massachusetts General Small *Municipal Separate Storm Sewer System (MS4)* permit. We use the town of Holden, Massachusetts to illustrate the process we went through in the development of Holden *MS4 Educational Video*. The target audience of the video we developed are the residents of Holden.

I. The Pre-Production Phase

A. Development of the video's concept:

According to the requirement in section 2.3.2.a of the 2016 MS4 permit, there are two main messages that should be included in the video:

1. The impact of stormwater discharges on water bodies; and
2. Steps and/or activities that the public can take to reduce the pollutants in stormwater runoff.

B. Development of the Storyboard:

The storyboard is an illustrated representation of what the video is intended to look like.

Link to how to make storyboard:
1. http://www.wikihow.com/Create-a-Storyboard

Link to storyboard making tools:
1. http://www.storyboardthat.com/

The following content includes references from "wikiHow - How to Create a Storyboard"

To make a storyboard, you should start with three steps:

1. Establish a timeline

The timeline that we used in *Holden MS4 Educational Video* is:
1. What is stormwater runoff?
2. The impact of stormwater runoff.
3. What is an MS4 permit?
4. The relationship between stormwater runoff and the MS4 permit.
5. The requirements in the MS4 permit.
6. What the town has done to protect water bodies?
7. Actions activities that the public can take to reduce stormwater pollution.
8. Credits

2. **Identify the key scenes in your story**

The key scenes in *Holden MS4 Educational Video* are:

- **Landmarks in the town of Holden**
    a. It is important to make the video locally, so the local residents will feel connected and be more persuaded to protect their own community.
- **Stormwater runs into stormwater drains**
  Map of the town of Holden with catch basins and outfalls
    a. It is important to show that the stormwater runoff and dumps flow into storm drains will enter nearby waterbodies untreated.
- **Impaired water bodies/Good water recreation areas**
    a. Communities with serious impaired water bodies - show the public the impacts and send the message that we need to change this situation
    b. Communities without impaired water bodies - send the message it takes great effort to maintain
- **The work that the town's *Department of Public Works (DPW)* does to help protect water bodies**
    a. If possible, a town official should talk about it, because they are more likely to inspire action
    b. Decide if you want the interviewee to read a prepared script or speak freely on certain topics. Prepare in advance.
- **Activities that the public can take to reduce the pollutants in stormwater runoff.**
    a. Showing both proper and improper actions right after each other is a good way to highlight what citizens should be doing (ex. Show someone dumping pet waste in a storm drain, then show them disposing of it properly)
    b. Clearly indicate which method is correct and which is incorrect

3. **Sketch and/or describe what will be included in each scene**

C. Script:

To develop the script, we followed the timeline detailed above. Here are potentially helpful resources:

- For general information:
http://nemo.uconn.edu/tools/app/raingarden.htm
http://www.northlandnemo.org/watershedgame.html
http://www.commonwaters.org/billion-gallons-a-year-campaign/about-billion-gallon-a-year

- What is stormwater runoff?

https://www3.epa.gov/caddis/ssr_urb_is1.html

- The impact of stormwater runoff.
https://www3.epa.gov/caddis/ssr_urb_is1.html

- What is MS4 permit?
https://www3.epa.gov/region1/npdes/stormwater/MS4_MA.html

- The relationship between stormwater runoff and MS4 permit.
https://www3.epa.gov/region1/npdes/stormwater/MS4_MA.html

- The requirements in the MS4 permit.
https://www3.epa.gov/region1/npdes/stormwater/MS4_MA.html

- The actions that the public can take to reduce the pollutants in stormwater runoff. (See http://web.uri.edu/riss/ for additional information)

    - We chose to target the residents and highlighted the following activities:

        i. **Better car washing practices**
            1. Wash on lawn instead of on pavement
            2. Use pH neutral and phosphate free soap
            3. Waterless car wash soap works as well

        ii. **Lawn care**
            1. Use slow-release fertilizer
            2. September is the best month to fertilize your lawn

        iii. **Do not dump into storm drains**
            1. This goes straight to waterbodies untreated
            2. Dispose of pet waste properly

        iv. **Rain gardens, rain barrels, and other low impact developments can reduce stormwater runoff**

For suggestion on more topics that the video could include for residents/businesses/developers /industrial facilities in the community check section 2.3.2.d in the 2016 MS4 permit.
https://www3.epa.gov/region1/npdes/stormwater/ma/2016fpd/final-2016-ma-sms4-gp.pdf#page=28

D. Shot list:

After creating the storyboard and the script, we created a shot list of all the footage we needed for the video. Making a shot list can help reduce the time spent taking footage since it is easier to get all the footage at once, rather than making multiple trips as the video progresses. To make the shot list, it is important to refer to the script because the video footage should match the script.

E. Personnel:
1-2 people.

F. Facilities:
HD video camera, microphone.

II. The Production Phase

A. Video Footage

I. Lighting: Make sure the scenes have proper lighting. Having a scene that is too bright or too dim can make it difficult to draw the viewer's attention to the proper person or object
II. Always take shots from multiple angles

B. Sound

I. Use an appropriate microphone for recording sound. If you are conducting an interview, it may be best to use a wireless microphone to capture the interviewee.
II. Time the script - This helps estimate how long each scene should be, and makes lining up video footage with talking much easier in post-production
III. Reduce background noise if possible. If you are recording a voiceover, make sure there is no background noise

III. The Post-Production Phase

A. Suggested tools: There are no special requirements for video making software. Though the options are plentiful, here are three software we found to easily meet all requirements:

iMovie - for Mac
Link to tutorial video for iMovie:
https://www.youtube.com/watch?v=kCq2ncg7Mqg

Adobe Premiere Pro - for Mac and Windows
Link to tutorial video for Adobe Premiere Pro:
https://www.youtube.com/watch?v=wK3JTh2jOf8

Camtasia Studio - for Windows
Link to tutorial video for Camtasia Studio:
https://www.youtube.com/watch?v=mH1mdGhjqls

We used Adobe Premiere Pro to make the video. Link to *Holden MS4 Educational Video*:
https://www.youtube.com/watch?v=JKuJNfCoqDI

Appendix G: Contacts and links to existing resources

This appendix includes some existing resources that municipal officials can use to help comply with *Public Education and Outreach* minimum control measure in the 2016 Massachusetts *Municipal Separate Storm Sewer System* permit.

Phone Apps:
Name: Rain Garden
Contents: Guide for residents on how to install a rain garden at home.
Developer: Connecticut *Nonpoint Education for Municipal Officials (NEMO)*
Link: https://itunes.apple.com/us/app/id588712983?mt=8

Websites:
Name: Rhode Island Stormwater Solutions
Contents: Activities that the public can do to help reduce stormwater runoff
Developer: Rhode Island NEMO
Link: http://web.uri.edu/riss/

Name: Billion Gallons a Year (BGY) Campaign
Contents: Information for homeowners/businesses/municipal boards/communities to help maintain water quality
Developer: Massachusetts Watershed Coalition
Link: http://www.commonwaters.org/billion-gallons-a-year-campaign/about-billion-gallon-a-year

Name: Nonpoint Source (NPS) Outreach Toolbox
Contents: Tools that help develop effective outreach
Developer: *United States Environmental Protection Agency (USEPA)*
Link: https://cfpub.epa.gov/npstbx/index.html

PDF file:
Name: Watershed Game
Contents: An interactive, educational tool that helps individuals understand the connection between land use and water quality
Developer: Northland NEMO
Link: http://www.northlandnemo.org/watershedgame.html