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Somerville Stormwater Management IQP

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Recommendations for Updates to the Stormwater Management Policy in Somerville, MA

An Interactive Qualifying Project Report submitted to the Faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science

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Abstract

This Interactive Qualifying Project, conducted with the help of Somerville Department of Public Works, reviewed the stormwater management policy in Somerville, Massachusetts. Working from case studies and guidelines from the Massachusetts Department of Environmental Protection (MDEP), Somerville's stormwater management policy was analyzed and recommendations were presented.

Acknowledgements

We would like to thank Professor Paul Mathisen for providing us guidance and support throughout this project to ensure we met all of our goals. His interest in helping us improve the overall quality of our project made a huge difference and we truly appreciate it. We would also like to thank the city of Somerville's Department of Public Works head engineer, Rob King. Despite his busy schedule, Rob was able to provide us with extremely useful information and guidance for our project. We also want to give a special thanks to Pierre Beliziarre for all of the assistance he provided our group with throughout this entire project.

Thank you for all of your help,

Nick Chambers, Craig Melillo, and Matthew McCarthy

Executive summary

The current storm water policy in the city of Somerville, MA is a one page document, created in 2005, that lacks detail in the regulations required for potential parties that fall under its jurisdiction. The document does, however, provide regulations regarding the ratio of I/I (inflow and infiltration) to be removed for any party adding a new sanitary connection to the Somerville sewer system that would exceed 2000 GPD, while also citing new regulations that have been issued by the Massachusetts Department of Environmental Protection (MDEP). After feedback from engineers within the Somerville Department of Public Works was received, it was determined that the current storm water policy for Somerville, MA was insufficient and was in need of recommendations and more detailed regulations. In comparison to neighboring communities, such as Cambridge, MA, Somerville's storm water policy appeared incomplete in the constraints given to those under its jurisdiction, and it needed to be revised to provide the structure that is found in more detailed storm water policies.

This Interactive Qualifying Project (IQP) was completed to give recommendations for potential changes to the city of Somerville's Storm Water Policy, using a cost benefit analysis approach with research on storm water management and analysis of storm water management projects as support. The foremost concepts considered for recommendation were the new storm water management standards issued by the MDEP in2008 and the evaluation of the efficiency of Somerville's 4:1 I/I mitigation ratio.

Before any recommendations were made, research was completed to gain knowledge on storm water and its effects on urban environments, like Somerville, as well as the environmental importance of efficient storm water management techniques. The major effects of storm water on urban areas resulted from impermeable surfaces causing runoff storm water to collect vast amounts of sediment and debris. This collection of debris and dirt would ultimately enter surface bodies of water and contaminate the water supply of that body. In addition, urban areas were subject to combined sewage overflows (CSO's), which occurred during heavy rainstorms when combined sewer systems were unable to handle the amount of sewage flow. CSO's can cause flooding and considerable property damage.

The methods used to control these problems are considered stormwater management techniques, and the techniques most often used are called best management practices (BMP's). It is crucial to find the most efficient strategy to manage stormwater and improving storm water quality. This process invokes the consideration of economic consequences, convenience and effectiveness. Projects considered during this process range from environmentally-friendly, low cost designs LID's (low impact design) to high cost, high yield projects like the installation of separated sewer systems.

After research on storm water and storm water management was completed, research was conducted on information regarding the current regulations for storm water management in Massachusetts. The memorandum of storm water regulations from the MDEP in 2008 was studied, and the regulation changes that were identified focused on five main goals:

- Increase in recharge of storm water
- Promotion of LID

- Confirmation of redevelopments consistently handling storm water more effectively
- Improvements for water sanitation
- Reflection of modern technology in new projects.

Once research regarding the basic background information was completed, the remaining steps to completing recommendations for the city of Somerville were formulated into a methodology. The methodology contained six tasks to be completed:

- Research general effects of storm water
- Research and evaluate storm water management policies
- Identify and assess case studies regarding storm water in urban areas
- Assess storm water impacts under current policies
- Evaluate impacts associated with storm water control with cost implications on development projects
- Write report/Present recommendation

Following the methodology, the analysis of the new standards proposed by the MDEP's most recent policy issued in 2008, was completed. There were ten standards that had been evaluated based on the differences seen from the former MDEP standards composed in 1996. While no major changes were seen in some of the MDEP Standards many of the Standards saw significant changes.

Contributing further to the analysis for the recommendations for Somerville's storm water policy were the case studies conducted on the developments in Somerville at the MaxPac project site and the Assembly Square project site. The MaxPac Square development is an example of a recent development in Somerville, Massachusetts that has been affected by Somerville's storm water management policy. MaxPac square is located on 56 and 62 Clyde Street and includes 25 housing units and 15 town homes. The development also includes a weight room, yoga studio, a chef's kitchen, new additions to Somerville's Community Path, a theater, a wireless work area and open green space ("Residential Project Known as MaxPac in Somerville to Break Ground"). The MaxPac Square project relies on several different BMPs to assist in meeting storm water regulations. These BMPs include subsurface infiltration areas, water quality inlets, area drains, and deep sump hooded catch basins.

Assembly Square Plaza is another recent development in Somerville that is under construction. It is located at the intersection of the Fellsway (Route 28) and Mystic Ave. It is already is a popular shopping district with retail stores like T.J Maxx. The project proposed to complete the development allots up to 52 new units that includes restaurants, fast food, condos, hotels, offices, retail stores, apartments, and condos. This development is adjacent to the Mystic River, which makes it subject to increased water pollution and flooding.

The MaxPac development was analyzed according to the affects that the newly issued MDEP standards would have on developers managing storm water. It should be noted though, that the MaxPac development is not located near nor does it contain any resource areas defined in the Massachusetts Wetlands Regulation so it is not subject to the MDEP standards. Although, the development still met many of the standards.

Some of the measures taken to meet these standards were:

- A storm water management design able to control 2, 10, and 100 year 24 hour storm events.
- Impervious area reduction and use of StormTech Chambers for ground water recharge
- 80% of Total suspended solids removed using deep sump hooded catch basis and Stormceptors.

The Assembly Square development was analyzed according to the measures taken to meet the 4:1 I/I mitigation ratio in comparison to meeting different ratios; 1:1 and 6:1. The projects completed to meet the 4:1 ratio combined on and off site projects. On-site projects included sewer system replacement, removal of illicitly connected catch basins, and a project completed at a CSO called the Somerville Municipal Conduit. Off-site projects were completed in the Ten Hills neighborhood, a neighborhood adjacent to the project site and the Mystic River, which was in need of sewer relining and manhole replacement. In addition to the projects completed on and off of the project site, a sewer fee was paid to the city of Somerville because there were not enough viable options for I/I mitigation projects to be completed to meet the 4:1 I/I mitigation ratio.

The costs of the projects completed at both project sites were estimated using prices gathered from discussions with engineers from various firms, such as the Somerville DPW, The Stormceptor System, the Sammamish Plateau Water and Sewer District, and the Rhode Island Department of Transportation. These costs were compared to the benefits associated with reduction of MWRA costs stemming from decreased flows to the

MWRA sewer system. This comparison led to the following recommendations regarding the city of Somerville’s storm water policy:

- Update the language of the Somerville’s storm water policy by mandating the ten MDEP standards issued in 2008
- Maintain 4:1 I/I mitigation ratio
- Perform I/I mitigation projects on all major sources of flows discharged into Somerville sewer system within the boundaries of a new development with minimum of 4:1 removal rate

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1. Introduction

Excess storm water has been plaguing societies with problems since the establishment of even the earliest civilization. Brought on by high precipitation, excess storm water causes flooding, combined sewer overflows and contamination to surface water bodies, which are all detrimental to society. To counteract these problems, governments at the federal, state, and local levels have created policies that place restrictions on activities that relate to storm water.

In Massachusetts, storm water management policies are influenced by the Massachusetts Storm water Management Standards and the Massachusetts Stormwater Handbook set forth by the Massachusetts Department of Environmental Protection (MDEP). Over the years the MDEP has revised these items in order to promote low impact development (LID), increase stormwater recharge, improve runoff treatment techniques, reduce pollution, remove illicit discharges, meet regulations of the Wetlands Protection Act and improve best management practices, or BMPs (MDEP, *Massachusetts Stormwater Handbook).* Since stormwater standards and regulations are becoming more stringent as more information regarding the impacts of stormwater runoff is gathered, it is imperative for cities and towns to update stormwater management policies to meet current rules and regulations.

The effects of stormwater runoff differ depending on the type of community being analyzed. Urbanization can have a dramatic effect on hydrology and is very present in Somerville, Massachusetts. Somerville is regarded as one of the most densely populated cities in the country. The urbanization of Somerville overtime has sparked a large increase in development and has had adverse effects on stormwater management throughout the city. Due to the large amount of development in the city, the Office of Sustainability and the Environment determined that 73 percent of the land in Somerville is impervious. Somerville's high population and highly developed area, make it imperative for the city to have a consistently updated stormwater management policy.

Somerville's current policy was published on January 1, 2005. Since this date, new standards and regulations have been set forth by the MDEP. As a result, Somerville is in need of an updated policy which considers all new standards and regulations. Stormwater management policies also have dramatic effects on new development. In a city that is constantly adding new development it is very important to implement new and improved stormwater management policies. It is also important for residents and developers in an urban city like Somerville, to understand how improvements to their cities current stormwater management policy may effect and change how new development is regulated. In this particular IQP, the storm water policy of Somerville, MA will be examined and possible improvements will be formulated.

1.1 Goal of IQP

The goal of this IQP is to update Somerville's storm water policy and assess its impacts on stakeholders. This will be done by evaluating two recent developments in the city. The specific objectives are to:

- State effects of storm water on urban areas
- Gather information from storm water policies in surrounding cities
- Review case studies to show how suggestions would affect Somerville Developments
- Compare other policies to Somerville Storm Water Policy

- Review 2008 MDEP Stormwater Management Policy and other Massachusetts Storm Water Regulations.
- Suggest revisions for Somerville's Stormwater Policy

This project is being done with the intent of presenting all findings and opinions to the Department of Public Works in the city of Somerville, MA in the spring of 2012. This target audience has been selected because of the direct relation between the goal of updating the Somerville Storm Water Policy and the past, present, and future work completed by the Somerville DPW.

1.2 Project Overview

From meetings and interviews with the head engineers in the Somerville Department of Public Works, it was concluded that the current storm water policy of Somerville had areas in need of improvement. Using information gathered from field observations combined with existing, this project is focused on updating the storm water policy for the city of Somerville, Massachusetts. While the current policy has sufficed since its composition in 2005, new updates aim to bring it in accordance with the current Massachusetts Department of Environmental Protection's storm water policy. Through the use of a cost benefit analysis approach, possible scenarios for how Somerville's storm water policy have been composed and evaluated. Each scenario has been evaluated from a stakeholder's perspective with economic implications in mind. The scenarios range from minimal inexpensive updates to extreme alterations with little regards to costs. These findings are based on the interpretations of case studies, in depth research into the storm water treatment, and the information provided by the Somerville DPW. This project was completed with the idea of presenting recommendations to the city of Somerville concerning a dated stormwater management policy.

2. Literature Review

2.1 Storm Water Overview

The key objective of this project is to assist Somerville, MA in updating its policy to become more efficient in how it handles storm water. To meet this objective, it is important to have a strong back ground on storm water, its effects, and how storm water is currently treated. This section gives insight into all of these key aspects.

2.1.1 Storm Water

Storm water is created from rain, snowmelt, or any other form of precipitation that does not get directly deposited into surface bodies of water or discharged into the ground. The most significant problem caused by storm water runoff is the flow of storm water over impermeable surfaces. When storm water flows over such surfaces (paved roads or parking lots) it accumulates pollutants and harmful debris from the ground; upon its discharge into larger bodies of water, it contaminates the water supply of whatever body it eventually flows into. The contamination of major bodies of water leads to an unsafe living environment.

Storm water treatment is a major priority for urban areas with water contamination problems. The United States EPA has cited storm water as a leading cause behind the pollution of fresh water sources. To combat this problem, city public works programs have been treating storm water using various methods to reduce its pollutant levels. The primary method of treating storm water discharges is the use of best management practices (EPA, *National Management Measures to Control Nonpoint Source Pollution from Urban Areas*).

2.1.2 Combined Sewage Overflows

A combined sewage overflow takes place during a heavy rain or a period with a high volume of precipitation. Combined sewer systems are sewer systems designed to collect rainwater, runoff, sewage and wastewater from industrial plants or construction sites and transport them to a wastewater treatment plant (WWTP). However during periods of high precipitation, the water emptying into combined sewer systems exceeds the capacity of the system and the system overflows. When this occurs, the excess water overflows into pipes that empty directly into surface water bodies, like rivers, streams or oceans. This overflow presents a serious problem for the environment because the water being dispersed into these natural bodies of water is highly contaminated.

Consisting of storm water, untreated human and industrial waste, and even toxic materials, this excess water contaminates fresh water supplies that both humans and other organisms rely on during everyday activities. In addition to water contamination, CSO's increase the water levels in surface bodies which can cause detrimental flooding. Flooding caused by CSO's can result in significant property damage and destruction of the environment. Ideally, underground sewer systems should

Figure 1-CS0 (Great Lakes. *Addressing Sewage Overflows*)

be constructed with separate pipes to prevent CSO's from occurring, but the earliest sewer systems used combined pipes making CSO's a common problem. Unfortunately, restructuring pipes is an extremely expensive project thus causing CSO's to still be a major problem in the society. In the US alone there are 772 cities currently facing CSO problems today.

2.1.3 Storm Water & CSO's Connection

Storm water's relation to the occurrence of CSO's is directly correlated due to the fact that as storm water levels increase, CSO's occur much more frequently. Increasing storm water levels raise water levels in sewers with combined pipe systems, causing contaminated water to spill over into natural surface waters. This contaminated water is made up of toxic wastes that are harmful to the environment. As this overflow occurs, it simultaneously contributes to runoff storm water collecting debris before it enters surface bodies of water. The diagrams below and on the next page illustrate processes that occur under dry and wet weather conditions in combined sewer systems and separate sewer systems.

2.2 Best Management Practices (BMPs)

The use of BMP's is crucial to finding the most efficient strategy to controlling storm water and improving its quality. This idea invokes the consideration of money, convenience and effectiveness; and below is a description of the most eco-friendly solution that is currently in use that encompasses those principles. In urban settings like Somerville, BMPs are typically used to remove pollutants by the following processes:

- Sedimentation- Removal of suspended particles from storm water by gravity settling
- Flotation- Separating of particulates with specific gravity that is less than water
- Filtration- Removal of particulates by passing the water through a porous media
- Infiltration- Reducing the volume of runoff that is being discharged to receiving waters by infiltration to the ground
- Absorption: Dissolved metals contained in storm water can be bound to the clay particles as the runoff percolates through clay soils in infiltration systems
- Biological uptake and conversion- Microorganisms can be used to degrade toxins and other pollutants
- Degradation- occurs through volatilization and hydrolysis

(Dzurik, 2002)

Source reduction is often used to reduce degradation of urban storm water. Source reduction can occur through a number of methods. These methods include:

- limiting the use of pesticides
- Implementing street sweeping schedules
- Collecting and disposing of lawn debris
- Periodic cleaning and maintenance of catch basins
- Setting regulations to eliminate potentially harmful chemicals into storm drains
- Discovering and eliminating any cross-connections between sanitary sewers and storm sewers (difficult in Somerville because most of the city has a combined sewer system)

(Dzurik, 2002)

There are 2 types of BMPs that are used to deal controlling storm water and improving its overall quality. The two types are structural BMPs and non-structural BMPs.

2.2.1 Structural BMPs

Structural BMPs are used to reduce the contamination levels in stormwater runoff. Infiltration systems, detention systems, retention systems and filtration systems are commonly used methods for contamination reduction.

2.2.2 Non-Structural BMPs

Non-Structural BMPs are used to reduce pollutants in stormwater runoff without the need of construction. Methods that are commonly used are educating the public about the effects of stormwater runoff, recycling, and maintaining the structural BMPs that are in use. (Dzurik, 2002)

2.3 Decreasing Impervious Area

The largest contributor to the amount and speed of water flowing off a site is the amount of impervious surface (Durham PWD, *Stormwater Services*). When natural groundcover is present 25 percent of rain infiltrates into the aquifer and only about 10 percent ends up as runoff (Ruby, *How Urbanization Affects the Water Cycle)*. In an area like Somerville which consists of around 73 percent impervious area, it is not unusual to see over 55 percent of rain fall end up as runoff (See Figure 2).

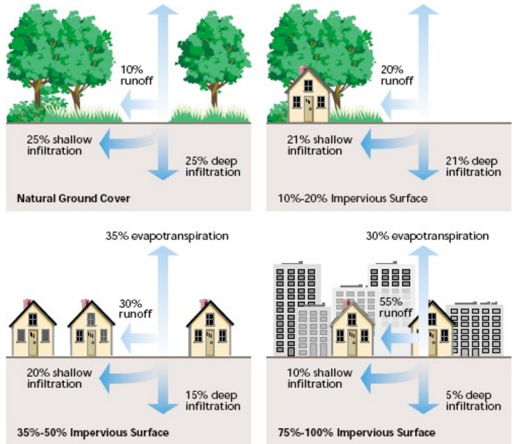

Figure 2 - Effect of Impervious Area (Lake County Watersheds. *Impervious Area Reduction)*

Some of the impacts that may result from Impervious Surfaces in Somerville include the following:

- Flooding- Since Somerville consists of mostly combined sewer systems, pipes may not have the capacity to hand intense storm events.
- Neighboring Properties-Not all stormwater is sent to the streets in the city. In some cases the runoff is sent to neighboring properties. When this occurs it could result in basement flooding as well as negative effects on lawns. This is common when small projects do not obtain special permits and alter landscapes and watercourse.
- Temperature Effects – Impervious areas such as asphalt driveways tend to have higher temperatures from sun exposure.
- Aesthetics- The increase in parking and decrease in green space from impervious areas may not be aesthetically pleasing to some.

(Lake County Watersheds. *Impervious Area Reduction)*

2.4 LIDs

Low impact design is a type storm water management technique that aims to mimic how storm water is managed naturally by the environment. The goal of an LID is to collect, filter, evaporate, store and detain runoff storm water. This idea is centralized on the notion of managing storm water in smaller, cost-effective, systems that provide minimal disturbance to the environment. This becomes an alternative to storm water management systems involving large, expensive facilities that collect storm water through sophisticated pipe systems that are difficult and expensive to install. The natural structures used in LID's are called Integrated Management Practices, and urban areas offer lots of potential IMP's. Examples of possible IMP's located within urban areas are any undeveloped open spaces, i.e. rooftops, parking lots, and sidewalks. This is especially significant when considering the use of LID's in Somerville, as it is a well-developed urban city that experiences the negative effects of storm water and CSO's.

The benefits of using the Low Impact Design approach as opposed to alternative structures are that it is an environmentally friendly design. By collecting runoff at its source by manipulating the environment and employing intelligent site design, LID's increase wellness in the environment for humans and other natural organisms. In today's society it is difficult to balance working within the constraints of eco-friendly regulations while also keeping a realistic budget. LID solves both of these problems and because it is patterned after naturally occurring storm water management systems has little effects on the environment.

2.4.1 Subsurface Infiltration Units

Subsurface chambers are usually used in parking lots to maximize land use while providing a significant amount of stormwater storage capacity (StormTech, *StormTech SC-740 Chamber)*. In an urban setting such as Somerville, this is a productive method for a developer. An example of what these chambers may look like during the construction of a project can be viewed below.

Figure 3-StormTech Chambers (StormTech, *StormTech SC-740 Chamber)*

It is common for operation and maintenance plans to require that inspections and maintenance are performed for all chambers after all major storms within the first 3 months of operation. In most cases, a major storm is when there is rainfall greater than 3 inches in a 24 hour period. After the initial 3 month period, most plans require that the units are checked at least twice a year. The inspections conducted in the 1st 3 months of operation are conducted to ensure that the subsurface infiltration units are properly functioning. Methods used to ensure this include observing the chambers at several time intervals during both small and large storms to make sure everything is functioning smoothly. In addition to this, inspectors should note how long the water stays in the chambers after storms and how well the water infiltrates over a period of 48 to 72 hours.

During the Semi-annually inspections, inspectors are expected to remove any debris that could clog inlet and outlet pipes, remove any tree seedlings located above the system, and to ensure that no ponding is occurring in the units 72 hours after a storm event.

2.4.2 Stormceptors

Stormceptors are a trademarked product from the Imbrium Company. These water quality inlets are designed to take in stormwater and remove sediment from it. This is down in the Stormceptor via the use of a swirling current. The water enters the unit and is forced into a vortex, in which much of the sediment in the water sinks to the bottom. This reduces the amount of sediment in this water, as much as 80% TSS removal of it stated by the Stormceptor Company.

Figure 4 – Stormceptor Unit (Stormceptor. *The Stormceptor System)*

Due to the fact that these units collect so much sediment, they need to be cleaned frequently. During the first few years they should be inspected every six months to see when the sediment needs to be cleaned out. From this information a schedule can then be created for the cleaning of these units. Units should be cleaned once the sediment depth reaches 15% of storage capacity. This should also be done by a third party waste management company. Figure 4 is an example of a stormceptor.

2.4.3 Deep Sump Hooded Catch Basins

A deep sump hooded catch basin is a catch basin is a large tank into which stormwater flows. This catch basin has an outlet pipe in it that is hooded. This hood goes over the outlet pipe and into the water line, thus not letting in any floating debris. When the stormwater flows into the tank, the water and sediment separate. The sediment settles at the bottom of the tank while the water is then pumped out of the basin through the outlet pipe. This is a way to turn ordinary catch basins into basins that not only store excess stormwater, but also filter the sediments out of the water before disposing of it outside of the system. Deep sump hooded catch basins can be attributed with a 25% TSS removal rate when used as a pretreatment method for stormwater.

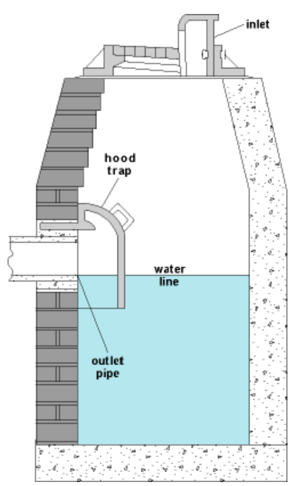

Figure 5 – Deep Sump Hooded Catch Basin (MDEP. *Structural BMP Specifications for the Massachusetts Stormwater Handbook*)

These basins need to be inspected and cleaned four times per year. These also need to be cleaned when the sediment level reaches one half of the distance from the bottom of the invert to the lowest pipe in the basin.

2.5 Infiltration and Inflow

Infiltration and inflow, I/I, are leading causes to combined sewer overflows and sanitary sewer overflows, which are some of the most prominent problems surrounding storm water. While infiltration and inflow are commonly associated together, they differ in their roots.

Infiltration is ground water that enters into sewer systems from pipe systems with cracks and leaks. This occurs whenever pipes are located below ground. It is a relatively slow process that occurs daily, but over the course of a year it accumulates to large amounts. In fact, infiltration composes 44% of the yearly flow in the Massachusetts Water Resources Authority, MWRA, sewer systems.

Similar to infiltration, inflow is precipitation or surface water that enters into sewer systems through cracked or leaky pipes. Inflow of rain water and other surface waters occurs less frequently than infiltration, but when inflows take place it occurs at a rapid rate. The highest levels of inflow are seen during and after heavy storms, and it can cause both CSO's and SSO's. While high levels of inflow are the result of illegal connections to sewer systems, its presence comprises 8% of the MWRA yearly flow.

The combination of inflow and infiltration make up approximately 52% of the annual flow in the MWRA sewer systems which comprise a large majority of the sewer systems in place in Somerville (Pearlman, *Minimizing Municipal Costs for Infiltration and Inflow Remediation*). The MWRA makes money by charging cities for using their sewer systems; this structure significantly depends on the volume of total sewer flow in a city.

2.6 Stormwater in Somerville

In this section Somerville's current stormwater management policy and the 2008 MDEP's Stormwater Management Standards are analyzed. The objectives of the policy and the standards were outlined.

2.6.1 Stormwater Management Policy for Somerville, Mass

Under Somerville's current storm water policy from January 2004, the city no longer allows new storm sewer connections to its current system. Refusal of new connections is due to capacity problems throughout the system as well as issues with flooding during large storm events. New sanitary sewer connections for flows over 2000 gallons per day require a "4 for 1Infiltration/inflow removal quality for a permit. In an effort to avoid flooding problems, the Somerville Zoning Ordinance (SZO) forbids development impacts to abutters (owners of property that touches on another's property), city systems and water quality. The SZO encourages diversion, detention, retention while mandating maximum groundwater recharge without any increase in both runoff amounts and velocities at site boundaries.

Somerville's policy contains standards which address water quality and water quantity. The standards concerning water quality deal with pollution while standards concerning water quantity relate to flood control. These standards are based off the Massachusetts Department of Environmental Protection's (DEP) state level storm water management policy which was issued in 1996 and new regulations which have been promulgated since. Local authorities are responsible to implement the policy under the Wetland Protection Act and the Clean Water Act. The City Engineer's office is responsible to enforce a suspension on new storm drainage connections and to review all development proposals in light of the most stringent interpretation of the storm water regulations set forth by the SZO and DEP for water quality and quantity.

On the next page, figure-4 is a copy of the current storm water policy currently in use in Somerville, MA.

CITY OF SOMERVILLE, MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS

JOSEPH A. CURTATONE
MAYOR

STAN KOTY
Commissioner

RICK WILLETTE
Director of Operations

January 1, 2005

TO: INTERESTED PARTIES
FR: CHARLES E. O'BRIEN, P.E., CITY ENGINEER
RE: STORMWATER MANAGEMENT POLICY

Since 1990, the City Engineer has refused permits for new storm sewer connections to the city system. Capacity problems cause combined sewer overflows into local water bodies plus flooding of basements and properties during every significant rain event. New sanitary sewer connections for flows over 2000 gpd require " 4 for 1 " I/I (infiltration/inflow) removal to qualify for a permit.

To mitigate problems, the Somerville Zoning Ordinance forbids adverse development impacts to abutters, city systems and water quality; the SZO encourages diversion, detention, retention, and mandates maximum groundwater recharge, with no increase in runoff amounts or velocities at site boundaries.

At the state level, Massachusetts Department of Environmental Protection issued a Stormwater Management Policy in November 1996, covering standards, applicability, planning and best management practices. New regulations have been promulgated. The standards address both water quality (pollution) and water quantity (flood control), and local authorities are empowered under the Wetlands Protection Act and the Clean Water Act to implement the policy.

Therefore, in view of increased environmental regulation and in the interests of public health and safety, it shall continue to be the policy of the City Engineer's office to enforce a moratorium on storm drainage connections, while reviewing all development proposals in light of the most stringent interpretation of the SZO and DEP stormwater regulations for water quality and quantity.

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WWW.CI.SOMERVILLE.MA.US

Figure 6 - Somerville Stormwater Policy

2.6.2 Massachusetts DEP Storm Water Policy

In 2008, the MDEP published improved storm water standards for Massachusetts (MDEP, *Changes to the Massachusetts Stormwater Management Standards).* The policy includes changes from the former policy which was put in place in 1996. Somerville's current storm water management standards are based on the DEP'S 1996 policy.

2.6.3 2008 Storm Water Standards-DEP

The Massachusetts Department of Environmental Protection (MDEP) Storm water Policy of 1996 established Storm water Management Standards designed to facilitate recharge and prevent storm water discharges from polluting the surface waters and ground waters in Massachusetts environments. However, in 2008 they revised these standards to meet the increasing concerns of pollution in Massachusetts surface and ground waters. The updated "standards" in the January 2008 Massachusetts Storm Water Policy focus on five main goals:

1. **Increase recharge of storm water**: recharge of storm water increases the ground water runoff and increases to the flow of local rivers and streams.
2. **Promote LID (low impact design):** using LID and BMP (best management policies) reduce the increase of water-proof surfaces and the disconnecting of drainage pathways that detract from recharge of storm water and increase pollution.
3. **Ensure redevelopments consistently improve handling of storm water**: Because of the lack of specificities in the 1996 Storm Water policy regarding redevelopment projects, the revised 2008 version aimed to strengthen regulations

for redevelopment projects. This was done through establishing requirements to always meet current standards, continuously improve current standards and also gives plans on how to make sure these improvements are made.

4. **Improve Water Sanitation**: As runoff storm water infiltrates local bodies of water such as streams, rivers and lakes, it not only increases water levels but it also increases the amount of pollution in these bodies of water. The MDEP has observed that treating the water for decontamination before it enters other bodies of water is much easier and more cost effective than treating the water after it makes its way into the environment.

5. **Reflect science since the mid-1990s**: The revised 2008 Massachusetts Storm water Handbook includes handling the removal TSS removal rates and new BMPs that reflect scientific studies of storm water from the past decade.

The research presented above in the literature review helped lead to the identification of the major tasks needed to complete this IQP. The next chapter, the methodology, is the outline of these tasks.

3. Methodology

In order to meet this IQP's goal of providing new updates to the Somerville Storm Water Policy, six tasks were identified. These tasks helped lead to the compilation of potential updates for Somerville's Storm Water Policy. Upon the completion of the first five tasks, an in depth report presenting the findings was formulated. The six tasks were:

1. Research general effects of storm water
2. Research and evaluate storm water management policies
3. Identify and assess case studies regarding storm water in urban areas
4. Assess storm water impacts under current policies
5. Evaluate impacts associated with storm water control with cost implications on development projects
6. Write report/Present recommendation

1. Research general effects of storm water

Researching and gathering information about the core topic, storm water, was the initial step in accomplishing the overall goal. To thoroughly research storm water, it was essential to study information posted by the most influential environmental agencies currently working within the storm water field, such as the EPA (Environmental Protection Agency,) MDEP (Massachusetts Department of Environmental Protection) and other groups with similar ambitions. Online sources were primarily used in research on storm water, while ensuring each site in which information was gathered from is reliable. From the research, the major problems associated with storm water in urban areas were cited. The vast majority of the findings in completing this task contributed heavily to the literature review.

2. Research and evaluate storm water management policies

To research and evaluate storm water management policies, information was gathered regarding storm water. In completing this task the research was concentrated specifically on storm water management policies. Most notably, the focus was on the storm water policy of Somerville, MA, which was composed in 2005 and based on the regulations set forth in MDEP policy from 1996. With the most recent MDEP policy having been issued in 2008, the emphasis of this task was placed heavily on how the new regulations from the 2008 MDEP policy differed from the 1996 policy, and how their differences relate to Somerville's current policy. To better understand storm water policies of urban areas, other urban cities close to Somerville, such as Cambridge, were studied with focus placed on how storm water and CSO's affected these policies.

3. Identify and assess case studies regarding storm water in urban areas

After gathering background information on storm water and storm water policies, case studies in major new developments in Somerville were examined. From these case studies, the multitudes of problems caused by the flow of contaminated storm water into clean water sources were identified. In addition to observing common problems associated with storm water, the different possible solutions to these problems were recognized, as well. Using findings from these case studies, along with findings from tasks one and two, the effects of these problems on Somerville were identified. The case studies that were obtained for this specific project include the MaxPac Square development and the Assembly Square development.

4. Assess storm water impacts on Somerville under current policies

In collaboration with Somerville's Water Department within the Department of Public Works, data based on the effects of storm water in Somerville was researched. This included acquiring information about flooding and CSO's, reviewing the sewer plans for new developments, and the implementation of BMP's to treat storm water. This helped in analyzing Somerville's plans in combating storm water, and provided a base point to identify how Somerville can improve their treatment of the flow of storm water back into surface waters.

5. Evaluate impacts associated with storm water control with cost implications on development projects

In order to conduct cost/benefit analysis for storm water management in Somerville, it was vital to consider costs associated with development projects. By doing this, the costs of meeting current storm water regulations were generated. In addition to evaluating the current cost associated with development, the cost for more or less stringent regulations was determined. This was completed by analyzing two recent developments in the city. These projects include the MaxPac Square development and the Assembly Square development. In order to evaluate these impacts and costs the following steps were taken:

a. Summaries of each development were generated. These summaries include what exactly is being proposed for both projects. Summaries of what BMPs are being used for each development are also provided.
b. It was determined if each development is meeting Somerville's current storm water management policy and if each development is meeting the requirements set forth by the Massachusetts Stormwater Handbook. This was completed by determining whether or not the new development is meeting the current Massachusetts Department of Environment Protection's Stormwater Management Standards and if the proposed development will meet the 4:1 I/I removal regulation in Somerville's current policy.
c. The costs associated with the BMPs used for each development were determined. The costs associated with meeting the 4:1 I/I requirements and the MDEP's stormwater standards for each development were also determined. Once these costs were generated, they were compared with more and less stringent regulations.

When the cost/benefit analysis was conducted, a net benefit analysis approach was employed which calculated the difference between the total cost and the total benefits for the regulations under review. Each development was reviewed and the data was used to analyze the costs associated with developments under Somerville's current policy. This information provided guidance to selecting a policy that is both reasonable and practical with regards to cost.

6. Write report

After gathering all necessary information regarding the effects of storm water, storm water policies in Somerville and other urban areas, and its effects on stake holders in Somerville, the results were evaluated to meet the project objectives. Once each objective was successfully met, a final report was composed. The report contained several layers, the first being an introduction that stated the project goal and the primary tenets that fall within that goal. The introduction was followed by the literature review which was designed to educate readers who may not be familiar with the concepts of storm water treatment, and inform the reader of the effects storm water has on urban areas. Third, a thorough procedure outlining each and every step taken to complete the project was formulated; citing the approach to different problems.

The final task to complete within the project is to present the results to an audience. The target audience is the people who work within the Department of Water in Somerville. With the intent to present the final conclusions in hopes that they may be of use in the City of Somerville’s approach toward storm water treatment.

4. Project Results

The city of Somerville's current stormwater management policy was published on January 1st, 2005. Since this date, the MDEP has made updates to their stormwater management standards. In order to compare Somerville's stormwater management policy to current regulations, the changes made to stormwater management regulations since the year 2005 needed to be identified.

4.1 Massachusetts Department of Environmental Protection-Storm Water Standard Updates

The updates from the 2008 MDEP Policy addressed the ten standards in 1996 policy, and while some endured very minor changes, others were drastically altered. The following is a summary of the 10 standards and how they have changed from 1996 to 2008.

STANDARD 1 (No major changes from 1996)

- No new storm water conveyances may discharge untreated storm water wetlands and waters of the commonwealth and also cannot cause erosions.

STANDARD 2 (No major changes from 1996)

- Storm water management policies must include Post-development discharge rates not exceeding pre-development peak discharge rates.
- The DEP uses this standard to prevent storm damage and downstream and offsite flooding from the 2-year and the 10-year 24-hour storm events, and that the 100-year 24-hour storm event must be evaluated to demonstrate that there will not be increased flooding offsite, with all downstream impacts carefully considered.

STANDARD 3

- The goal of this standard is to eliminate or minimize the loss of annual recharge to groundwater by using infiltration techniques. The post-development annual recharge site shall approximate the annual recharge from pre-development site based on soil type. This standard has had some major changes since 2006 and is included in the table below.

Table 1: Standard 3 Requirements – Recharge Requirements per Soil Type

NRCS Hydrologic Group	1996 Volume Requirement	2008 Volume Requirement
Soil Type A- includes gravels, sand, loamy sand or sandy loam	0.4 inches	0.6 inches
Soil Type B- includes silty loam	0.25 inches	0.35 inches
Soil Type C- sandy slay loam	0.1 inches	0.25 inches
Soil Type D- clay silty clay loam, sandy clay, silty clay	Not Required	0.10 inches

(MDEP, *Changes to the Massachusetts Stormwater Management Standards)*

STANDARD 4

- Storm water management systems must be designed in order to remover 80% of the average of annual post construction loads of Total Suspended Solids. To meet this standard the following items need to be addressed:
    - A long term pollution prevention plan must be composed to effectively prevent pollution and manage source control. This plan must be updated and implemented.

- Storm water best management practices are put in place and capture the required water quantity outlined in the Massachusetts Storm Water Handbook.
- Appropriate pretreatment practices are taking in accordance with the Massachusetts Storm Water Handbook

STANDARD 4 CHANGES WITH RESPECT TO WATER QUALITY

- Major changes include the following, an increase in the emphases on source controls, Requirement of a long term prevention plan regarding pollution, updated best management practices and total suspended solids table, revision of some total suspended solids removal efficiencies, additional charts outlining removal efficiency potential beyond TSS

STANDARD 5

- Put forth for land uses with higher potential pollutant loads
- Changes to the plan include required treatment of at least a pretreatment and terminal treatment BMP, 44% TSS removal is required for pretreatment train before infiltration occurs, roof top runoff from metal roofs and industrial buildings are no longer considered to be a land use with higher potential pollutant loads, and hazardous waste site will be added to land uses with higher potential pollutant loads

STANDARD 6

- Storm water discharges to critical areas require the use of specific source control and pollution prevention tactics which are determined by the DEP to be suitable by the Massachusetts Storm Water Handbook.

STANDARD 6 CHANGES REGARDING CRITICAL AREAS

- 44% TSS removal is needed for pretreatment before infiltration also a source control and pollution prevention program must be implemented and include the proper management of snow and other chemicals

STANDARD 7

- Redevelopment project must meet Standard 2, Standard 3 and the pretreatment and structural storm water best management practice requirements outline in Standards 4, 5 and 6.

STANDARD 7 CHANGES

- Projects must meet standards to maximum extent practicable as well as improve existing conditions, flexibility must exist so improvements can be made to site conditions, guidance on retrofits must be provided and guidance must be provided to assist in determining if the project complies with the standards while improving existing conditions

STANDARD 8

- Controls construction related impacts, which include erosion, sedimentation and other pollutant sources that construction may be result it. Also control land disturbance activities including a pollution prevention plan and period erosion need to be developed and implemented

STANDARD 8 Changes

- The construction phase must include an erosion control plan or a Storm Water Pollution Prevention Plan

- For land disturbances greater than or equal to one acre, a copy of NPDES Construction General Permit must be submitted to commission (if SWPPP is required by EPA)
- Once document can be used in order to satisfy both requirements

STANDARD 9

- A long term O&M (Operation and Maintenance) Plan needs to be developed and implemented to ensure that storm water management systems operate/ function as they were originally designed

STANDARD 9 Changes

- Tighter O&M requirements to ensure treatment, recharge, source controls and peak rate control over long term
- Require rolling log to be maintained of O&M activities for 3-year periods
- Log must be available to Conservation Commissions and the MDEP if requested
- BMPS must be maintained and cannot alter BMP unless there is a Conservation Commission review
- Town agency must have opportunity to sign off on O&M plan.

STANDARD 10 (no changes)

- All illicit discharges to the storm water management system are prohibited.

(MDEP, *Changes to the Massachusetts Stormwater Management Standards)*

4.1.1 Impacts of 2008 Policy on Development in Somerville

The updated standards will significantly affect any proposed updates to the Somerville policy, which will have major implications on potential new developments in Somerville. When evaluating potential new storm water policy updates for Somerville, it is important to look at the impacts they will have on new developments. The Massachusetts Department of Environmental Protection has issued ten standards within its new policy for the Commonwealth of Massachusetts to abide by.

Since some standards have remained the same since the MDEP's policy issued in 1996, these standards have already been included in Somerville's current storm water management policy. These standards include both Standard 1 and Standard 2. In relation to Standard 1, any type of new development cannot discharge untreated water or cause any type of erosion directly to wetlands or waters in the commonwealth. This means that drainage plans from new development cannot carry untreated water to local bodies of water. Standard 2 relates to new development by mandating that new development peak discharge rates must be less than pre development peak discharge rates. This means that new development must find ways to maintain lower discharge rates than the discharge rates from the site that existed before the development took place.

Other standards that relate to development have undergone both minor and substantive changes from 1996 to 2008. In this case, Somerville's current policy does not always incorporate these types of changes when it comes to new development. Standard 3 is an example of a standard that impacts development and has undergone revisions from 1996 to 2008. Standard 3's goal is minimize annual loss of recharge to ground water. This effects new development by promoting environmentally friendly site designs. This standard forces new development to pay close attention to infiltration. When new development takes place low impact development (LID), best management practices (BMP) and a high level of efficiency will be necessary in order to meet this standard. Like Standard 2, Standard 3 new development must maintain lower discharge rates than the previous conditions based on soil type (changes to soil type regulations are in table in standards summary). Standard 3 also includes that any development with discharge rates higher than 2.4 inches per hour, must remove 44% of the total suspended solids (TSS) prior to discharge to the infiltration structure that is being used.

Standard 4 has a major impact on new development as well. Standard 4 suggests that storm water management systems are required to remove 80% of TSS after construction. These systems also must be an ordinance with the Massachusetts Storm water Handbook. The 2008 version of this standard puts a much stronger emphasis on source controls and BMPs. It also suggests that the developers provide a long-term pollution prevention plan. Standard 5 relates to areas with higher pollutant loads and suggests that these areas shall reduce storm water runoff from these areas to best extent possible. This standard is further outlined in the Massachusetts Storm Water Handbook as well and has undergone some changes from 1996 to 2008. Such changes include, at least some form of pretreatment and terminal treatment to the water that is being discharged and 44% TSS removal before infiltration. Like Standards 4 and 5, Standard 6 also deals with best management practices for discharges in relation to critical areas. Changes from 1996 to 2008 with respect to this standard regarding critical areas include, 44% TSS removal before infiltration and all new development projects must have a source control and a pollution prevention program implemented.

Standard 7 relates to new development by suggesting that redevelopment must meet standard 2,3,4,5 and 6 to maximum extent practicable. Changes from 1996 to 2008 in relation to standard 7 and redevelopment include, improvements to previous conditions, flexibility to new changes, and providing guidance to whether or not a redevelopment project meets current standards put forth by MDEP.

For purposes of the Storm water Management Standards redevelopment projects are defined to include the following:

1. Maintenance and improvement of existing roadways including widening less than a single lane, adding shoulders, correcting substandard intersections, improving existing drainage systems and repaving;

2. Development, rehabilitation, expansion and phased projects on previously developed sites, provided the redevelopment results in no net increase in impervious area; and

3. Remedial projects specifically designed to provide improved storm water management such as projects to separate storm drains and sanitary sewers and storm water retrofit projects." (MDEP, *Changes to the Massachusetts Stormwater Management Standards)*

Standard 8 suggests that new development must provide a plan to control construction related impacts. These impacts include erosion, sedimentation, and other sources of pollutants during the construction phase of a project. Changes that have been made to this standard in relation to new development include, an erosion control plan, a construction general permit, and developers must provide one document meeting both of the previously mention requirements. Standard 9 suggests that a long term operation and maintenance plan must be provided and implemented by developers as well. Changes to this standard in relation to development include, more stringent requirements for the plan, a rolling log for a 3 year period which must be made available to MDEP and conservation commissions upon request, maintain BMPS and the town/city must be given the chance to sign off on the proposed plan.

4.2 Case studies

Somerville's stormwater management policy is unique because projects must meet the stormwater management standards set forth by the MDEP and a 4:1 infiltration and inflow requirement. In order to evaluate how these changes have impacted development in the city of Somerville, 2 projects within the city were analyzed. The MaxPac Square project was evaluated to determine if the project was following current MDEP stormwater standards. In addition to meeting these standards, the project was also analyzed to ensure that it met the 4:1 infiltration and inflow required by Somerville's Stormwater Management Policy. The Assembly Square project was also evaluated to ensure that the 4:1 infiltration and inflow requirement was being met.

4.2.1 MaxPac Square Development

MaxPac Square is an example of a recent development in Somerville, Massachusetts that has been affected by Somerville's stormwater management policy. MaxPac square is located on 56 and 62 Clyde Street and includes 25 housing units and 15 town homes. The development also includes a weight room, yoga studio, a chef's kitchen, new additions to Somerville's Community Path, a theater, a wireless work area and open green space ("Residential Project Known as MaxPac in Somerville to Break Ground"). The MaxPac Square project relies on several different BMPs to assist in meeting stormwater regulations. These BMPs include subsurface infiltration areas, water quality inlets, area drains, and deep sump hooded catch basins.

Figure 7 - MaxPac Square-(Wilson, *Speak Out for Somerville Jobs at Public Hearing on MaxPac*)

4.2.2 Assembly Square Project Site

Assembly Square Plaza is another recent development in Somerville that is under construction. It is located at the intersection of the Fellsway (Route 28) and Mystic Ave. It is already is a popular shopping district with retail stores like T.J Maxx. The project proposed to complete the development allots up to 52 new units that includes restaurants, fast food, condos, hotels, offices, retail stores, apartments, and condos. This development is adjacent to the Mystic River, which makes it subject to increased water pollution and flooding.

Figure 8-Assembly Square (Hassett, *Magistrate rules against IKEA, city still hopeful*)

4.3 Meeting Standards and I/I Mitigation for MaxPac Square Development

This section goes into detail on how the MaxPac Square project is meeting the current MDEP stormwater management standards and Somerville's 4:1 I/I mitigation regulation.

Table 2: Summary of MDEP Stormwater Standard Fulfillment

STANDARD 1	N/A
STANDARD 2	In order to maintain peak discharge rates, the stormwater management design will control 2-, 10-, 100 –year and 24-hour storm events
STANDARD 3	Post development site will reduce impervious area on site by 0.66 acres. Site will also include 164 StormTech Chambers which will be described later in the report. These chambers will recharge groundwater on the site. The annual recharge will increase or at least remain the same from the sites previous conditions.
STANDARD 4	The MaxPac Square will try to meet this standard to the maximum feasible extent. Most of the site will comply with 80% TSS removal but there are small locations in front of garage entrances for some of the buildings where untreated runoff will be discharged into the drainage system. This as well as some of the BMPs being used to treat some of the discharging stormwater on the site will be discussed later on in the report.
STANDARD 5	N/A
STANDARD 6	N/A
STANDARD 7	As a redevelopment project, MaxPac Square fully complies with all standards set forth by the MDEP with the exception of Standard 4(which the project complies with to the maximum extent feasible.)
STANDARD 8	A Stormwater Prevention Plan was developed and implemented
STANDARD 9	A long term Operation and Maintenance Plan was developed
STANDARD 10	There is no illicit discharges to the proposed stormwater management system

4.3.1 MaxPac Square Development-Meeting MDEP Standards

As mentioned previously, the MDEP's stormwater standards play a significant role in how developers plan to control stormwater runoff. While looking into MaxPac Square it is important to consider that the project is not required to follow the standards set forth by the DEP since the site is not located near and does not contain any resource areas defined in the Massachusetts Wetlands Regulation. Although this is true, the project still does meet the standard updates that were set forth in 2008 by the MDEP. A storrmwater management report prepared by Beals and Thomas, INC. examines how each standard is met and are summarized in Table 2 (Standards 1, 5 and 6 did not apply with this specific development).

Meeting Standard 2

According to the report prepared by Beals and Thomas, INC, calculations prove that post-development discharge rates do not exceed predevelopment rates for the 2-year and 10-year 24 hour storm events. In cases where there was an off-site flooding increase during the 100-year 24-hour storm event, calculations also proved that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Meeting Standard 3

Standard 3 requires that the annual recharge will increase or at least remain the same from the previous conditions of a site. This is done by setting certain volume requirements based on soil types. Table 1 was first introduced when this project was being developed, and plays a major role in measuring whether or not a development meets the required recharge volume set by Standard 3.

Table 1: Standard 3 Requirements – Recharge Requirements per Soil Type

NRCS Hydrologic Group	1996 Volume Requirement	2008 Volume Requirement
Soil Type A- includes gravels, sand, loamy sand or sandy loam	0.4 inches	0.6 inches
Soil Type B- includes silty loam	0.25 inches	0.35 inches
Soil Type C- sandy slay loam	0.1 inches	0.25 inches
Soil Type D- clay silty clay loam, sandy clay, silty clay	Not Required	0.10 inches

Table 1 displays how volume requirements in relation to soil types have changed from 1996 to 2008. The MaxPac Square development meets the 2008 volume requirement set forth by the MDEP stormwater management standards.

The MaxPac Square development uses soil type C which is sandy clay loam. Since the volume requirement is 0.25 inches and the amount of proposed impervious area is equal to 167,840 square feet, the required recharge volume is equal to 3,497 cubic feet. The MaxPac Square development uses 2 methods to meet this requirement.

One method being used is reducing the amount of impervious area. The proposed development will decrease on site impervious area by 0.66 acres while the proposed community path will increase impervious area by 0.19 acres. Overall the project will result in a decrease of 0.47 acres of impervious area. It has been calculated that reduction in impervious area on the site accounts for 601 cubic feet of recharge volume. In addition to impervious area reduction, the 164 subsurface infiltration chambers (StormTech chambers) are a major contributor to meeting the required recharge volume of 3,497 cubic feet. The subsurface infiltration basins account for 12,545 cubic feet of recharge volume which results in a net recharge volume of 13,147 cubic feet for the proposed project. 13,147 cubic feet is greater than 3,497 so Standard 3 is being met. Table 3 illustrates how Standard 3 is being met.

Table 3: Calculations for MaxPac Square Development, Standard 3

Soil Type	C
2008 Volume Requirement (Inches)	0.25
Proposed Impervious Area (ft^2)	167,840
Required Recharge Volume from Standard 3 (ft^3)	3497
Recharge Volume from Impervious area Reduction (ft^3)	12,545
Recharge Volume from Subsurface Infiltration Units (ft^3)	601
Total Recharge Volume From Development (ft^3)	13,146

Meeting Standard 4

Similar to Standard 3, Standard 4 puts a good amount of pressure on developers to meet regulations through the use of BMPs. Standard 4 requires stormwater management systems to be designed for removal of 80% of the average annual post-construction load of Total Suspended Solids (TSS).

Calculations suggest that the total TSS removal at the MaxPac Square development is at 83%. Since the regulated lowest amount for TSS removal is at 80%, the MaxPac Square development meets this requirement. This requirement is met using two BMPs, deep sump hooded catch basins and Stormceptors. Table 4 shows how this requirement is being met at the MaxPac development:

Table 4: Calculations for MaxPac Development, Standard 4

Standard 4 Calculations for MaxPac Development					
	A	B	C	D	E
	BMP	TSS Removal Rate	Starting TSS Load	Amount Removed	Remaining Load
1	Deep Sump Hooded Catch Basin	0.25	1	0.25	0.75
2	Stormceptor	0.77	0.75	0.5775	0.1725
TSS **Removal Rate**		0.8275			
83%					

Meeting Standard 7

Standard 7 requires the MaxPac development to meet the MDEP Stormwater Management Standards to the maximum extent practicable. This standard is indeed being met by these developers. In fact, the development fully complies with every standard with the exception Standard 4. As mentioned, there are some areas with pre-existing conditions that may not always meet the 80% TSS removal. However, this analysis indicates that this Standard is being met to the maximum feasible extent; therefore the development complies with all the standards set forth by the MDEP.

Meeting Standard 8

In order for developers to comply with Standard 8, a long term pollution prevention plan was developed. This plan includes the following:

- Certain materials and waste products should be under cover
- No vehicle washing will take place on site
- Routine inspections and maintenance of stormwater BMPs
- Contingency plan must be made to address the spillage of hazardous materials
- Fertilizers, herbicides, and pesticides, should be stored in accordance with local regulations.
- Pets should be cleaned up after on the premises
- Septic systems should be served by a municipal sewer collection system
- Solid waste should be removed and disposed of by a waste hauler
- Street sweeping should take place 4 times a year

Meeting Standard 9

As for Standard 8, Standard 9 also requires developers to come up with a long term plan. Standard 9 requires developers to generate a long-term operation and maintenance plan and implement it. This plan includes an outline of the best management practices associated with identifying and scheduling inspection and maintenance activities. These BMPs include subsurface infiltration areas, water quality inlets, area drains, and deep sump hooded catch basins. The responsibilities belong to KSS Realty Partners to provide this information. The material that KSS Realty Partners is mandated to keep includes a log of all inspections, repairs and disposal relevant to the stormwater management system. Inspection and Maintenance schedules are also expected under this standard. The following demonstrates what is expected:

- Area drains – inspected and cleaned yearly
- Deep sump hooded catch basins – inspected and cleaned out 4 times a year
- Water quality inlets – maintenance performed according to manufacturer
- Subsurface infiltration units – inspections and maintenance after every major storm
- Snow and Snowmelt Management – removal every spring

This standard is proposed with public safety in mind.

Meeting Standard 10

Standard 10 did not apply to this development because no illicit discharges to the proposed stormwater management system were associated with this project.

4.3.2 MaxPac Square Development- Meeting the I/I requirement for the Existing Somerville Stormwater Policy

This proposed development will add 30,770 gallons per day of sanitary flow to the sewer system. This development, during peak use times, will also generate 0.25 cfs of sanitary flow. This is all made possible due to the fact that 99,434 gallons of stormwater storage will be available off site to satisfy the 4:1 Inflow and Infiltration Removal clause in the Somerville Stormwater Policy. Table 5 illustrates how this development is meeting the 4:1 I/I removal regulation:

Table 5: Meeting 4:1 I/I at MaxPac Development

I/I requirement	4 to 1
Gallons of Sewage being added (gallons)	30770
Gallons of Stormwater that must be removed	123080
Impervious Area Reduction Removal	23646
Subsurface Infiltration Chambers Reduction Removal (gallons)	93838
Minimum expectancy of new drainage reduction removal (gallons)	6000
Gallons of Stormwater being Removed (gallons)	123,484
Yes or No	Yes

4.4 Meeting Somerville's 4:1 I/I Mitigation Regulation in Assembly Square

This section goes into detail on what methods are being used to meet Somerville's 4:1 I/I mitigation regulation in the development of Assembly Square.

4.4.1 Existing Wastewater System at Assembly Square in Somerville, MA

All wastewater flows in Somerville are directed to the MWRA sewage system which runs to the MWRA treatment plant at Deer Island. The proposed sewers for the Assembly Square Project are separated systems; meaning wastewater and storm water are collected in separate systems within the area. The sewer system within the Assembly Square project area is also owned by the City of Somerville, and the system flows from three sanitary drainage area to three different MWRA connection points.

The project sewers that enter the MWRA system through MWRA-16 manhole discharge into the city of Somerville's regulator manhole before it enters the MWRA-16 manhole (located at North Union Street).The current Assembly Square Project area sewer system starts at Middlesex Ave and turns under Route I-93 to a manhole near the McGrath Highway connector, and then finally into an MWRA manhole located at the intersection of Mystic Ave and the McGrath Connector.

The remaining flows of the Assembly Square project area are serviced by an 8-inch sewer starting at the intersection of Middlesex Ave and Foley Street. This sewer discharges flows at the MWRA-14 manhole located at the intersection of Middlesex Ave and Mystic Ave (Vanasse Hangen Brustlin, Inc., 2008).

4.4.2 Assembly Square Project Estimates

At full build, the Assembly Square Project is projected to generate a peak sewer flow of 3.15 MGD. In the full build phase of the project, the project would require approximately 1.6 miles of newly installed sewer mains, varying in sizes from eight to eighteen inches in diameter, as well as manholes to accompany the new buildings that will be constructed.

The main sewer trunk for the project is located in the right of way of Assembly Square Drive. The trunk line begins near A Street and runs south to North Union Street.

From there, the sewer line connects to the City of Somerville's municipal sanitary sewer regulator manhole, which is located within North Union Street. In due course, this sewer line will empty the MWRA sewer system (Vanasse Hangen Brustlin, Inc., 2008).

4.4.3 Current Flows in Assembly Square Sewer System

The Assembly Square district used to be comprised of industrial office buildings, restaurants, recreational facilities, and retail stores. These building structures, prior to construction, produced over forty thousand gallons of water flow per day (40,291 GPD) (Vanasse Hangen Brustlin, Inc., 2008). Under the plans for construction, many of these flows will be removed and will contribute to the amount of flows required to be removed under the inflow and infiltration standard set forth in Somerville's policy. Table 6 outlines what flows will be removed and what will remain prior to the demolition of buildings in the project area.

The remaining 9,930 flows that will remain are not counted as flows added to the MWRA sewer system in Somerville, thus in the calculation of estimated flows, they will not be counted as additional flows added to the system.

Table 6: Flows Being Mitigated at Assembly Square Development

Building Identification	Building (SF. Ft.)	Flows Removed Phase 1 (GPD)	Flows Removed Full Build (GPD)	Flows to Remain (GPD)
85 Foley St – Cab Repair	3,677	0	800	
99 Foley St – Central Steel	53,908	0	417	
123 Foley St. Spaulding Brick	19,800	294		
147 Foley St. American Propane	1,050	79		
100 Sturtevant	26,532	508		
Yacht Club		0	0	800
Goodtime Billiards	109,232	24,750		
Boston Paintball	39,162	1,958		
World Gym	26,606	1,330		
Graybar	26,609	225		
Home Depot	147,608			7,380
Circuit City	33,488			1,675
Amelia Earhart Dam	1,000			75
Totals:		**29,144**	**1,217**	**9,930**

The estimated flows that will be added to the system have been calculated by the Vanasse Hangen Brustlin Group to total 746,755 GPD. This number was calculated using the Full-Build Building program and the wastewater generation rates specified by the state, with the consideration of a peaking factor of flow rates. The individual flows rates were based on state regulations 314 CMR 7.00 Sewer System Extension and Connection Program and 310 CMR 15.00 Title 5 for retail, office, restaurant, commercial, hotel, cinema, residential, industrial and marina uses; which have been established based on the observations of similar establishments that experience similar flows (Vanasse Hangen Brustlin, Inc., 2008). Table 7 displays the total flows associated with the full build phase of the development at Assembly Square, with the amount flows needed to be removed to meet the 4:1 ratio.

Table 7: Meeting 4:1 I/I Mitigation at Assembly Square

Project Design	**Peak Flows (GPD)**
Full Build	777,116
Existing Flow to be removed	30,361
Proposed Project Net Flow	746,755
Flow Requiring Removal	**2.99 MGD**

Given these estimates, the project developers at the Assembly Square district would be required to mitigate 2.99 MGD (millions of gallons per day). To meet this mitigation requirement the developers are working in accordance with the city of Somerville, the DEP and the MWRA. The mitigation program is based on citing the best locations within and adjacent to the project site that would allow for the elimination of I/I.

4.4.4 On Site I/I Mitigation Measures at Assembly Square

As part of the steps being taken to mitigate inflow and infiltration to meet the four-to-one standard, the pre-existing sewer system within Assembly Square is being completely replaced. In Phase 1 of the building project, the main trunk line for the sewer system was put in place with plans to add sewer lines and add additional sewer lines in later phases along A, C, D and Foley Street. In addition, a new drop sewer manhole was created adjacent to Somerville's regulator manhole. This drop sewer manhole connects to both the existing 24 inch sewer and the 18 inch sewer line that was created during Phase 1 of the project, and directs these flows to Somerville's regulator manhole and then eventually to the MWRA-16 manhole. Using a water metering system based on the principles laid out in the MDEP Guidelines for Performing I/I Analyses, these improvements to the onsite sewer system have been estimated to reduce the inflow and infiltration into the system by 0.078 MGD (Vanasse Hangen Brustlin, Inc., 2008).

Additionally, the other major onsite change that helped eliminate I/I was the removal of illicitly connected catch basins that were located on Mystic Ave, Lombardi Street, and Broadway. These illicitly connected catch basins are illegally connected catch basins that helped add thousands of flows per day to the MWRA system. The removal of these catch basins resulted in .294 MGD of I/I removal (Vanasse Hangen Brustlin, Inc., 2008).

4.4.5 I/I Mitigation in the Somerville Marginal Conduit

The Somerville Marginal Conduit is a combined sewer overflow that discharges combined flows of storm water and sewer water directly into the tidal portion of the Mystic River. The water that is discharged into the river is treated scarcely through screening and chlorination. The project that has been proposed to reduce these flows will employ a new 72-inch outfall pipe that will discharge treated storm water to a designated storm water outfall below the Amelia Earhart Dam. By using the new outfall pipe, I/I occurring as a result of the Somerville Marginal Conduit will be reduced by 1.2 MGD (Vanasse Hangen Brustlin, Inc., 2008).

4.4.6 Off-Site I/I Removal at Assembly Square

In order to achieve the 4:1 I/I removal ratio, the developers at Assembly Square will have to perform I/I mitigation projects away from the project site as well. The target site for these projects is the Ten Hills neighborhood which is located northwest of the project site on the opposite side of Route 28, which runs parallel to Assembly Square (Vanasse Hangen Brustlin, Inc., 2008).

The I/I removal project being suggested for the Ten Hills neighborhood is being divided into two separate projects; with one project taking place on the east side of the neighborhood and another project on the west side of the neighborhood. Both projects are set to accomplish the same goal. In both sides of the Ten Hills neighborhood the sewer and drainage pipes and the manholes will all be replaced.

In the west side of the Ten Hills Neighborhood the reconstruction of drainage systems and manholes will reduce the amount I/I in the sewer system by 0.305 MGD. In the east side of the Ten Hills Neighborhood, the drainage area is smaller than the west side, but because of sewer repairs from 2006 that occurred in the west side of the Ten Hills neighborhood, the expected removal of I/I to the system is the same at .305 MGD. This brings the total amount of I/I mitigation in the Ten Hills Neighborhood to .610 MGD.

4.4.7 Sewer Banking at Assembly Square

The total amount of flows to be mitigated through on and off site projects totals 2.18 MGD, which is 0.81 MGD less than the required amount to be removed (2.99 MGD).

However, the analysis of engineers working within the project has shown that there are no other areas within the realm of the project site that produce enough flows to warrant any form of major I/I flow removal. In a process called sewer banking, to meet the required mitigation rate of 2.99 MGD, the developers have agreed to pay a fee to the city of Somerville that will go toward other I/I mitigation projects around the city. This fee will take the place of the .81 MGD that were failed to be removed (Vanasse Hangen Brustlin, Inc., 2008). Table 8 is a table outlining the sources of all flows planned to be removed from the project:

Table 8: Proposed Mitigation at Assembly Square

Proposed Mitigation Project	**Flows Removed (MGD)**
On Site: Replacement of Sewer System	0.078
On Site: Disconnection of illicitly connected catch basins	0.294
Off Site: Ten Hills Sewer and Drain Replacements and Rehabilitation	0.61
Total Illicit Flow Removal	**0.98**
On-Site: Removal of Flows from Somerville Marginal Conduit	1.20
Financial Contribution Offset	0.81
Total Proposed I/I Removal for Full	**2.99**

4.5 Cost/Benefit Analysis for Case Studies

The main objective of this IQP is to make recommendations for updating the City of Somerville's Stormwater policy to be consistent with the new DEP guidelines. These recommendations were based off the cost benefit analysis of two specific case studies: the developments undergoing construction at Max Pac and Assembly Square. After identifying and estimating the costs of the developments at Max Pac and Assembly Square, the results were analyzed using a cost benefit comparative approach. The costs of meeting the Massachusetts Department of Environmental Protection's stormwater management standards and I/I mitigation regulations for the MaxPac Square Project have been estimated. The costs involved with meeting I/I mitigation regulations for the Assembly Square project have also been estimated. In this chapter, the analysis and method for estimating the costs and benefits at these two developments are presented, along with the recommendations for the City of Somerville's Storm Water Policy.

4.6 Cost/Benefit Analysis for MacPac Square Development

4.6.1 Cost of Meeting MDEP Standards for the MaxPac Development

Of the stormwater standards set forth by the MDEP, it was determined the cost associated with meeting Standards 3 and 4 must be considered. Standards 3 and 4 have a direct impact to the costs of the MaxPac Project while the other remaining standards do not. In order to examine the costs associated with meeting these standards, the costs relating to the BMPs used in the project were determined. Table 9 displays the cost for the BMPs and the cost for operation and maintenance of the BMPs.

Table 9: BMP Pricing

BMP Type	# of BMPs	Cost per Unit ($)	Annual Cost to Inspect and Maintain (For all BMPs) ($)
Stormceptors	5	6732	1,000
Deep Sump Hooded Catch Basin	7	595	1,400
StormTech Chambers	4 Sections (164 Chambers)	240 per chamber	1,200

The MaxPac development consists of 7 deep sump catch basins which have expected maintenance costs of $200.00 each. This results in a total cost of $1,400.00 per year to maintain the catch basins. The development also includes 5 water quality inlets (Stormceptors) which account for an annual maintenance cost of $200 each. This will result in a total annual cost of $1,000.00 for maintenance to the Stormceptors. The StormTech Chambers or Subsurface Infiltration Areas are an example of a best management practice or BMP. For the MaxPac development, the chambers are broken up into 4 separate BMPS with an annual cost of $300.00 each. As a result the total cost of maintenance for the chambers per year is $1,200. Combining these prices with the $1,000.00 annual maintenance charge associated with water quality inlets, the $500.00 annual charge with area drains maintenance and the $1,400.00 annual charge of catch basin maintenance, the total cost of operation and maintenance for stormwater related controls on the MaxPac project will equal $4,100.00 per year. Using the operation and maintenance costs as well as the costs per unit for the BMPs, the cost for meeting

Standards 3 and 4 was determined. Table 10 displays the costs associated with meeting Standard 3.

Table 10: Expenses Related to Meeting Standard 3

BMP Type	Impervious Areas	Subsurface Infiltration Chambers
Installation Costs (dollars)	0	67,500
Cost Per Unit (dollars)	0	240
Number of Units	0	164
Cost of Maintenance (per year)	0	1200
Total Cost for First Year (dollars)	0	108060

Since Standard 3 deals with recharge volume based on soil type, subsurface infiltration chambers were the only expense involved with meeting the standard. It was estimated that a total of 1350 yr^3 needed to be excavated in order to install all 164 chambers in the MaxPac project site. It was also estimated that 790 yr^3 of gravel and stone were needed to backfill the subsurface infiltration chamber fields. Using these results, it was estimated that it would cost $67,500 to install all of the chambers. The total cost per year of meeting Standard 3 for the MaxPac development was estimated to be $108,060 in the first year.

Since meeting Standard 4 deals with total suspended solids removal, deep sump hooded catch basins and stormceptors were the BMPs used to meet the 80% TSS removal requirement. Using the provided operation and maintenance values along with installation costs and costs per unit, it was determined that the total cost to meet Standard 4 for the MaxPac development would be equal to $112,225 in the first year. The following table displays the costs associated with meeting Standard 4 for each BMP used. In order for the MaxPac project to meet both Standards 3 and 4, the total cost for all BMPs used in the project would equal $220,285 in the first year.

Table 11: Expenses Related to Meeting Standard 4

BMP Type	Stormceptor	Deep Sump Hooded Catch Basin
Installation Costs (dollars)	6000	6000
Cost of Maintenance (per year)	1000	1,400
Total Cost for First Year (dollars)	64660	47565

4.6.2 Benefits of Meeting MDEP Standards for the MaxPac Development

The MaxPac Square project is not required to follow the standards set forth by the DEP since the site is not located near and does not contain any resource areas defined in the Massachusetts Wetlands Regulation. Although this is true, the project still meets the standard updates that were set forth in 2008 by the MDEP. By assuming it costs the city of Somerville $0.01 for every gallon of stormwater the MWRA treats, the city of Somerville will save an estimated $230,200 a year in treatment costs (Somerville Water and Sewer Department, 2011). Table 12 displays how the savings were calculated.

Table 12: Savings from StormTech Chambers

BMP type	StormTech Chambers
Water Recharged by BMP (Gallons)	93848
Price per Gallon of Treated Water (dollars)	0.01
Savings Per Day (Dollars)	630.68
Savings Per Year (Dollars)	230,198

Since $230,200 is greater than $220,285 the MaxPac project can expect a return on investment in an estimated 0.95 years. The reduction of hazardous flooding volume is another example of a benefit from meeting the stormwater management standards. The city of Somerville has a large flooding problem and a reduction in impervious area along with an increase in stormwater recharge volume decreases the amount of hazardous flooding in the city. The reduction of hazardous flooding for the MaxPac Square project is both a financial and social benefit to meeting the MDEP's Stormwater Management Standards. Meeting these standards also results in the developers providing the city of Somerville with an approved pollution prevention plan. A pollution prevention plan is another example of a benefit since it outlines exactly what steps will be taken to reduce the risks of pollution on the MaxPac Square site. This plan installs confidence to the residents of MaxPac and to city officials that the appropriate steps are being taken to reduce the risks associated with stormwater runoff to the maximum extent feasible.

4.6.3 I/I Costs for MaxPac Square

As mentioned previously Somerville's 4:1 I/I removal regulation is being met by the MaxPac Square project. In order to compare the costs of meeting more and less stringent I/I removal regulations, the costs associated with meeting 1:1, 4:1 and 6:1 I/I removals for the MaxPac Square project were determined.

4.6.4 Costs associated with meeting 1:1 I/I Mitigation

The total costs associated with all the BMPS used to meet 1:1 I/I Mitigation for the MaxPac Square project was estimated to be $1,042. Since StormTech Chambers, pipe improvements and reduction in impervious area were the only 3 factors that affected I/I mitigation for MaxPac, the costs were determined by measuring how many chambers are needed to meet the 1:1 standard. By determining the cost of installation per chamber, the cost of each chamber and the amount of gallons being recharged per chamber, the total costs associated with I/I Mitigation regulations for the MaxPax Square project were estimated. Table 13 displays the costs associated with meeting 1:1 I/I mitigation.

Table 13: Costs of Meeting 1:1 I/I Mitigation

BMP TYPE	StormTech Chambers
Gallons of Sewage being added	30770
Gallons of Stormwater Needed to Removed	30770
Gallons Removed Per Chamber	572
Impervious Area Reduction Removal (gallons)	23646
Pipe Improvements Recharge (Gallons)	6000
Gallons of Stormwater Needed to Removed from Chambers	1124
The Number of Chambers Needed	2
Total Cost with Installation (Dollars)	1042

4.6.5 Costs associated with meeting 4:1 I/I Mitigation

The total costs, considering all BMPs used on the project, associated with meeting 4:1 I/I Mitigation for the MaxPac Square project was estimated to be $85,103. It was assumed that minor pipe improvements would result in 6000 gallons of additional storage when these calculations were made. It was determined that 164 chambers would be needed in order to meet a 4:1 I/I mitigation regulation. Since 164 chambers were used in the MaxPac Square project, there is 4:1 I/I mitigation on the project site. Table 14 displays the results for 4:1 I/I mitigation at the MaxPac Square.

Table 14: 4:1 I/I Mitigation at MaxPac Square

BMP TYPE	StormTech Chambers
Gallons of Sewage being added	30770
Gallons of Stormwater Needed to Removed	123080
Gallons Removed Per Chamber	572
Impervious Area Reduction Removal (gallons)	23646
Pipe Improvements Recharge (Gallons)	6000
Gallons of Stormwater Needed to Removed from Chambers	93434
The Number of Chambers Needed	164

4.6.6 Costs associated with meeting 6:1 I/I Mitigation

The total costs associated with meeting 6:1 I/I Mitigation for the MaxPac Square project was estimated to be $141,156. It was assumed that minor pipe improvements would result in 6000 gallons of additional storage when these calculations were made. It was determined that 271 chambers would be needed in order to meet a 6:1 I/I mitigation regulation. Since 164 chambers were used in the MaxPac Square project, there is not 6:1 I/I mitigation on the project site. It was determined that it would cost an additional $56,053 to meet 6:1 rather than 4:1 I/I mitigation. Table 15 displays the results for 6:1 I/I mitigation at the MaxPac Square.

Table 15: 6:1 I/I Mitigation at MaxPac Square

BMP TYPE	StormTech Chambers
Gallons of Sewage being added	30770
Gallons of Stormwater Needed to Removed	184620
Gallons Removed Per Chamber	572
Impervious Area Reduction Removal (gallons)	23646
Pipe Improvements Recharge (Gallons)	6000
Gallons of Stormwater Needed to Removed from Chambers	154974
The Number of Chambers Needed	271
Total Cost with Installation (Dollars)	141156

4.6.7 Benefits associated with meeting 4:1 I/I Mitigation

By assuming it costs the city of Somerville $0.01 for every gallon of stormwater the MWRA treats, the city of Somerville will save an estimated $230,200 a year in treatment costs. Since $230,200 is greater than $220,285 the MaxPac project can expect a return on investment in less than one year. Since the StormTech chambers are the only financially measurable method to promoting stormwater recharge for the MaxPac Square project, the financial benefits for meeting the 4:1 I/I Mitigation requirement are the same as the financial benefits for meeting the MDEP's Stormwater Management Standards. Additional economic and social benefits from meeting Somerville's 4:1 I/I mitigation include the reduction of hazardous flooding from the MaxPac Square project. In urban areas with historic flooding issues like Somerville, it is important to reduce stormwater runoff leaving new developments. By removing 4 gallons of stormwater for every additional 1 gallon of sewage accumulated from a new development, flood risks are drastically reduced.

4.7 Cost/Benefit Analysis for Assembly Square Development

4.7.1 I/I Costs at Assembly Square

The projects to mitigate I/I at Assembly Square, along with the fee paid to the City of Somerville, referred to as sewer banking, and were collectively able to meet the 4:1 ratio. While the target number of I/I flows to be mitigated, 2.99 MGD, was unable to be met without the sewer banking fee, the analysis of costs was completed using a comparative approach of three ratios of I/I mitigation. The ratios selected were based on ratios in use by Somerville and other Massachusetts communities, and they are 1:1, 4:1, and 6:1. In the following sections, the costs associated with meeting an I/I removal ratio of 1:1, 4:1, and 6:1 for the developers at the Assembly Square Project Site are described.

4.7.2 Costs Associated with Meeting the 1:1 I/I Mitigation

The costs associated with meeting the 1:1 I/I mitigation ratio come from projects performed both on and off of the project site. The projects completed that helped the developers meet the 1:1 ratio were the on-site replacement of the sewer system, removal of illicitly-connected catch basins, and the off-site projects at the Ten Hills neighborhood.

Replacing the sewer system at Assembly square resulted in approximately 1.6 miles of sewer pipe ranging in sizes from eight to eighteen inches in diameter. Costs associated with the new sewer system at Assembly Square were estimated using a scaled map of the project site. A detailed map of the project site was provided by the Somerville DPW outlining where the newly laid pipes would be, along with the size of the pipes (diameter in inches). Using the approximated costs for sewer pipe installation with respects to engineering, permitting, construction, restoration, and inspection the average price for the installation of eight inch PVC sewer pipe was determined to be $426.00 (Tobin, Lisa. Interview). With little variation in costs between pipe installations of similar sized pipes, estimates of installation costs for larger pipes were based on differences in costs of materials. Table 16 lists the costs of specific pipe sizes and how much of that sized pipe was used during the construction of the Assembly Square sewer system:

Table 16: Costs of Specific Piping

PVC Pipe Diameter Size (inches)	Cost of Pipe (Per Linear Foot)	Total Costs Associated with Installation (Per Linear Foot)	Length of Pipe Installed on the Project Site (Feet)	Total Costs of Pipe Installation to Developers
8	$50.00	$426.00	4,580	$1,915,080.00
10	$70.00	$446.00	680	$303,280.00
12	$110.00	$486.00	1,050	$510,300.00
15	$130.00	$506.00	430	$217,580.00
18	$150.00	$526.00	1,670	$878,420.00
			Total Cost of Pipe Installation (On Site):	**$3,860,660.00**

(Rockville DPW. *Standard Prices for Cost Estimating*).

In addition to the new sewer pipes, the drop sewer manhole that was constructed adjacent to the city's regulator manhole and over the already existing 24 inch sewer is also part of the on-site projects to reduce I/I. Using estimates for drop manhole installations with respect to construction, labor, and maintenance, $7,500.00 (Dias, Jon. Interview) along with the cost per unit of a drop sewer manhole, $5,000, the total cost of that particular project was estimated to be $12,500.00 (Rockville DPW. *Standard Prices for Cost Estimating*).

The third project considered part of the on-site mitigation projects was the removal of illicitly connected catch basins to the Somerville sewer system. The costs resulting from this specific project consisted of three aspects; costs per day of investigation, costs per dye test, and construction cost per property. With the removal of several illicit connections, the costs associated with the removal projects were estimated to be $55,000.00. This brought the total on-site costs for I/I mitigation to $3,928,160.00. The amount of flows removed as a result of the on-site projects was only 0.37 MGD, however, the estimated $3.86 million spent on the new sewer lines was the most expensive project completed to meet the desired I/I ratios.

The remaining I/I flow left to be removed to meet the 1:1 ratio was accounted for in the projects completed in the Ten Hills neighborhood. As described previously, these projects consisted of the relining of sewer pipes and the replacement of the manholes in the neighborhood. Using the same estimation technique as the one used to determine the amount of pipe used in on-site projects, the length of sewer pipe to be relined was projected to be approximately 4,250 feet.

When relining sewer pipes however, there are two different methods that differ based on the condition of the pipes. These methods are trenchless relining and the conventional practice of digging up and repairing the pipes. The latter is more expensive with average cost per linear foot of pipe relining being about $160.00. The technique of digging up and repairing is used when the pipes in question are cracked or broken. On the other hand, the trenchless method, which involves less manual labor but more advanced technology, costs on average $82.50 per linear foot of pipe relining (Trenchless Sewer Repair. *Trenchless Sewer Line Services)*. Table 17 shows approximated costs of the pipe relining project using different methods:

Table 17: Costs of Different Piping Techniques

Cost of Trenchless Pipe Relining	**Cost of Conventional Pipe Relining**	**Cost of Combined Method of Pipe Relining**
$350,625.00	$680,000.00	$515,312.50

In the Ten Hills Neighborhood, fourteen manholes were cited for replacement. The estimated cost for replacement for one sewer manhole was $7,500, making the cost of this project $105,000 (Dias, Jon. Interview). This brought the total cost of the offsite project at the Ten Hills Neighborhood to approximately $620,312.00 for the mitigation of .61 MGD of flows

The combination of on and off site projects resulted in the removal of 0.98 MGD of I/I flows which met the 1:1 ratio by more than .23 MGD. The estimated total costs for the developers who completed these projects were $4,548,472.00. Using a cost per gallon of I/I flow removed, the estimated cost for removing the -necessary. With 0.746 MGD removed, the cost would be approximately $3,462,408.00. Table 18 showing the total costs associated with each project:

Table 18: Total Costs at Each Project

Project Description	**Project Costs**
On-Site Sewer System Repairs	$3,860,660.00
Illicitly Connected Catch Basin Removal	$55,000.00
Off-Site Projects at Ten Hills	$620,312.00
Total Project Costs	**$4,548,472.00**

4.7.3 Costs Associated with Meeting 4:1 I/I Ratio

The estimated costs associated with meeting the 4:1 inflow and infiltration removal ratio build on the estimated costs associated with meeting the 1:1 mitigation ratio. All the project costs described in the previous section are included in the estimated costs for the 4:1 ratio. The additional projects completed to meet the 4:1 ratio were the project at the Somerville Marginal Conduit that took 1.2 MGD, once discharged into the SMC, and treated it using a dedicated storm water outfall that discharged into the tidal portion of the Mystic River and the sewer banking project that consisted of a fee to be paid to the city of Somerville by the developers.

The estimated costs associated with the project completed at the Somerville Marginal Conduit are based on average costs from past projects and the amount of flows being managed by this project. The average cost per gallon of flow per day for an I/I mitigation project in Massachusetts is approximately $4.90, but based on cost estimations for the projects completed to meet 1:1 ratio, the average cost per gallon was found to be $4.64 (Pearlman. *Minimizing Municipal Costs for Infiltration and Inflow Remediation)*. The project completed at the SMC removed 1.2 MGD of I/I flows from the MWRA system, which would result in an approximate cost of $5,568,000.00, using the estimates from the projects completed at Assembly Square.

The combination of this project with the projects completed to meet the 1:1 ratio result in the mitigation of 2.18 MGD of I/I flows. This leaves 0.81 MGD of the 2.99 MGD of I/I flows left to meet the 4:1 ratio. Because there were no other major sources of flow discharge into the MWRA system identified the sewer banking fee was used to cover the remaining flows. Using average cost per gallon of flow per day for the I/I mitigation projects already completed, the estimated fee to be paid to the city of Somerville was $3,969,000.00. Table 19 shows the total costs of projects and fees used to meet the 4:1 I/I mitigation ratio.

Table 19: Total Costs of Meeting 4:1 I/I Mitigation

Project Description	**Project Cost**
Projects Completed to Meet 1:1 Ratio	$4,548,472.00
Project Completed at the SMC	$5,568,000.00
Sewer Banking Fee	$3,758,400.00
Total Cost:	$13,874,872.00

4.7.4 Costs Associated with Meeting 6:1 I/I Ratio

The estimated costs related to meeting the 6:1 I/I removal ratio at the Assembly Square project site are the costs needed to mitigate approximately 4.485 MGD of flows.

This cost is a combination of estimated expenditures of meeting the 4:1 ratio and the amount of money needed to complete projects that would remove 1.495 MGD of I/I flows. Because of the circumstances at the Assembly Square project site, the elimination of these flows would need to be dealt with through another fee paid to the city. Using the same method of cost estimation with the original sewer fee, the cost of eliminating 1.495 MGD of I/I flows would be $6,936,800.00. Table 20 shows the total costs of projects and fees used to meet the 6:1 I/I removal ratio.

Table 20: Total Costs of Meeting 6:1 I/I Mitigation

Project Description	**Project Cost**
Projects Completed to Meet 1:1 Ratio	$4,548,472.00
Projects Completed to Meet 4:1 Ratio (not considering projects used for 1:1 ratio)	$9,326,400.00
Fee Paid to meet 6:1 Ratio (not considering projects used for 4:1 ratio)	$6,936,800.00
Total Costs:	**$20,811,672.00**

4.7.5 Benefits of Meeting 4:1 I/I Mitigation

The estimated benefits of removing inflow and infiltration from the Somerville sewer system are based on the economic savings of flow reductions from the projects performed at the Assembly Square project site. By removing flows contributed by I/I that discharge into the Somerville sewer system, the city of Somerville saves on costs paid to the MWRA for water treatment at Deer Island.

On average, I/I remediation projects keep inflow and infiltration out of the sewer system for at least twenty years. Based on analysis of I/I mitigation projects, on average I/I mitigation projects save $0.57 per gallon of flow per day per year. Over the course of twenty years it would save approximately $11.40 per gallon of flow.

A net benefits approach was used to determine the estimated benefits of the I/I mitigation projects. A net benefits approach is difference between the total benefits and the total cost. Using the average savings per gallon per day per year of I/I mitigation projects, the tables below show the net benefits of completing projects to meet the three different I/I removal ratios: 1:1, 4:1 and 6:1. The table below shows the estimated net benefits over a twenty year period for the projects completed to meet the 1:1 I/I removal ratio.

Table 21: Cost/Benefit Analysis of 1:1 I/I Mitigation

Time of Use	**Total Benefits**	**Total Costs**	**Net Benefits**
1 Years	$558,600.00	$4,548,472.00	$-3,989,872.00
5 Years	$2,793,000.00	$4,548,472.00	$-1,755,472.00
10 Years	$5,586,000.00	$4,548,472.00	$1,037,528.00
15 Years	$8,379,000.00	$4,548,472.00	$3,830,528.00
20 Years	$11,172,000.00	$4,548,472.00	$6,623,528.00

Table 22 shows the estimated net benefits over a twenty year period for the projects completed to meet the 4:1 I/I removal ratio.

Table 22: Cost/Benefit Analysis of 4:1 I/I Mitigation

Time of Use	Total Benefits	Total Costs	Net Benefits
1 Years	$1,704,300.00	$13,874,872.00	$-12,170,572.00
5 Years	$8,521,500.00	$13,874,872.00	$-5,353,372.00
10 Years	$17,043,000.00	$13,874,872.00	$3,168,128.00
15 Years	$25,564,500.00	$13,874,872.00	$11,689,628.00
20 Years	$34,086,000.00	$13,874,872.00	$20,211,128

Table 23 shows the estimated net benefits over a twenty year period for the projects completed to meet the 6:1 I/I removal ratio.

Table 23: Cost/Benefit Analysis of 6:1 I/I Mitigation

Time of Use	Total Benefits	Total Costs	Net Benefits
1 Years	$2,556,450.00	$20,811,672.00	$-18,255,222.00
5 Years	$12,782,250.00	$20,811,672.00	$-8,029,422.00
10 Years	$25,564,500.00	$20,811,672.00	$4,752,828.00
15 Years	$38,346,750.00	$20,811,672.00	$17,535,078.00
20 Years	$51,129,000.00	$20,811,672.00	$30,317,328.00

The break-even point for when the estimated total benefits equal the estimated total costs (when the net benefits are zero) is at approximately 8.14 years from when projects are initially in use. Economic benefits would not be realized until the breakeven point; however the environmental impact from reduction of flooding and improved water quality would be experienced from the start.

5. Summary and Recommendation for Somerville's Stormwater Policy-Standards

5.1 Summary

The costs of the projects completed at both project sites were estimated using prices gathered from discussions with engineers from various firms, such as the Somerville DPW, The Stormceptor System, the Sammamish Plateau Water and Sewer District, and the Rhode Island Department of Transportation. These costs were compared to the benefits associated with reduction of MWRA costs stemming from decreased flows to the MWRA sewer system. These comparisons can be found in Sections 4.6 and 4.7. The comparisons led to the recommendations for the city of Somerville's Storm-water Policy in regards to MDEP standards and an efficient I/I mitigation ratio. The recommendations regarding the MDEP standards are from the most recently issued 2008 MDEP Regulations and the ratios for I/I mitigation evaluated are based on a ratio of flows to be removed to flows added.

5.2 Recommendations Regarding MDEP Storm Water Management Standards

After reviewing the MaxPac Square project it became clear that the development follows all updated MDEP stormwater management standards. The MDEP's stormwater standards are applied to areas subject to the jurisdiction under the Massachusetts Wetlands Protection Act. Although the MaxPac Square project was not considered part of this jurisdiction, the development abided by all 10 stormwater standards.

Somerville's current stormwater management policy does not contain any language dealing with these standards. Adding language concerning the MDEP's stormwater standards to Somerville's stormwater management policy would be beneficial for both developers and the citizens in the city of Somerville. Giving residents and developers a better understanding of what it expected by the Massachusetts Department of Environmental Protection will increase the efficiency of managing stormwater throughout the city. By mentioning the requirements set forth by the MDEP in Somerville's stormwater management policy, the city of Somerville will have a more thorough policy. The policy would include all regulations in the state of Massachusetts rather than just the regulations set forth by the city of Somerville.

5.3 Recommendation for Somerville's Stormwater Policy-I/I Mitigation Ratio

The analysis of the projects completed to mitigate inflow and infiltration at the MaxPac development and at the Assembly Square development lead to the determination that the 4:1 I/I mitigation ratio would be most efficient for the city of Somerville's stormwater policy. At the MaxPac project site, the 1:1 ratio did not comply with all of the standards recommended for Somerville's storm water policy, and the 6:1 ratio called for extremely high economic costs at the Assembly Square project site. The 4:1 ratio also made meeting Standard 3 from the MDEP's stormwater standards an easier process in the case of the MaxPac project. Since the project had to meet Somerville's 4:1 requirement, the amount of stormwater recharge needed to meet Standard 3 was easily managed. Standard 3 only requires the MaxPac development to recharge 26,156 gallons of stormwater based on soil type whereas the 4:1 regulation requires the MaxPac development to recharge 123,080 gallons of water. These results make it clear that in the case of the MaxPac development, 4:1 I/I mitigation is a more stringent regulation than Standard 3.

However, as seen in the projects at the Assembly Square development, the developers had to pay a fee to the city because there were no other major sources of sewage discharged in the vicinity of the project site. In addition to the 4:1 ratio, Somerville should consider requiring all new developments to have I/I removal projects performed on all major sources of flows discharged into the Somerville sewer system that are located on the project site. Even if it results in a higher ratio of flows removed than the current 4:1 ratio, it would maximize the actual mitigation of inflow and infiltration at all new developments. This would require a minimum inflow and infiltration removal rate of 4:1, with potential for more based on discharges of flows at project sites. If the city of Somerville were to accept the recommendations made for their storm water policy, all new developments would be subject to the following stormwater policy updates in Table 24:

Table 24: Effects of Stormwater Policy Recommendations

Stormwater Policy Update	**Effect**
Adjustments for MDEP Standards	
MDEP Standard 1	No new storm water conveyances may discharge untreated storm water wetlands and waters of the commonwealth and also cannot cause erosions.
MDEP Standard 2	Post-development discharge rates not exceeding pre-development peak discharge rates
MDEP Standard 3	Eliminate or minimize the loss of annual recharge to groundwater by using infiltration techniques
MDEP Standard 4	Storm water management systems must be designed in order to remover 80% of the average of annual post construction loads of Total Suspended Solids
MDEP Standard 5	Put forth for land uses with higher potential pollutant loads. Required treatment of at least a pretreatment and terminal treatment BMP, roof top runoff from metal roofs and industrial buildings are no longer considered to be a land use with higher potential pollutant loads, and hazardous waste site will be added to land uses with higher potential pollutant loads.
MDEP Standard 6	Storm water discharges to critical areas require the use of specific source control and pollution prevention tactics which are determined by the DEP to be suitable by the Massachusetts Storm Water Handbook.
MDEP Standard 7	Redevelopment project must meet Standard 2, Standard 3 and the pretreatment and structural storm water best management practice requirements outline in Standards 4, 5 and 6.
MDEP Standard 8	Controls construction related impacts, which include erosion, sedimentation and other pollutant sources that construction may be result it. Also control land disturbance activities including a pollution prevention plan and period erosion need to be developed and implemented
MDEP Standard 9	A long term O&M (Operation and Maintenance) Plan needs to be developed and implemented to ensure that storm water management systems operate/ function as they were originally designed
MDEP Standard 10	All illicit discharges to the storm water management system are prohibited.
Adjustments to provide adequate I/I Mitigation Controls	
4:1 I/I Mitigation	Developers must remove minimum of four gallons of I/I for every gallon of sewage added to the Somerville Sewer System
Mitigation of I/I on any major discharges	Any major sources of flows discharged into Somerville system must be removed to the greatest extent possible

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