CLIMATE CHANGE ADAPTATION PLANNING FOR MASSACHUSETTS DRINKING WATER AND WASTEWATER UTILITIES

An Interactive Qualifying Project submitted to
the Massachusetts Department of Environmental Protection
and to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the Degree of Bachelor of Science
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Date: May 4th, 2010

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Abstract

This project focuses on how MassDEP can provide assistance to water utilities for adapting to climate change effects such as sea level rise, an increase in storm intensity and rising temperatures. Through interviews with MassDEP water experts, water associations and utilities, we identified ways MassDEP can assist utilities in adapting to changing weather conditions. Our final deliverable is a list of recommendations of how MassDEP can provide assistance to utilities in need of protecting themselves against potential weather related threats.

Acknowledgements

We would like to first thank the Massachusetts Department of Environmental Protection for sponsoring this project and providing us with a workspace in their Boston office. We want to thank our liaisons, Douglas Fine and Ann Lowery, who were always helpful and gave us the insight to realize why this project was important to the agency. In addition, we would like to thank all of the people that we interviewed in MassDEP, from associations and from the utilities. We would not have been able to gather such helpful information without your help. A complete list of interviewees we would like to thank is presented in *Table 7*, located in *Appendix E*. Finally, we would like to thank our project advisors, Chrysanthe Demetry and Richard Vaz, for all of their support and feedback throughout the project.

Executive Summary

Scientific evidence has shown that the Earth's climate is changing. There have been signs of increasing temperatures, sea level rise, and increasing storm intensity over the past century. All of these climatic changes have the potential to harm drinking water and wastewater utilities, as shown in *Table 1*.

Table 1: Climate Change Impacts and Needed Actions

Climactic Change	Impact on Infrastructure	Action Needed
Increase in temperature	Earlier snow melt going into reservoirs	Increase reservoirs capacities
	Greater bacteria levels in drinking water	Treat water with more intense procedures
Sea Level Rise	Flooding of plant	Raise up vulnerable components
	Salt water intrusion	Treat water with more intense procedures
Increase in storm intensity	Flooding or inundation of plant	Raise up or upgrade vulnerable components
	Combined sewers will overflow	Separate combined sewer systems
	Stormwater drains become overstressed	Install larger pipes and drains

Because of these risks to utilities, our sponsor, the Massachusetts Department of Environmental Protection (MassDEP), asked us to provide recommendations on how to support Massachusetts drinking water and wastewater utilities in adapting to climate change. First, we completed background research on how other communities around the nation have prepared climate adaptation plans, as well as on communities that have plans in the making. Because most of these plans do not focus specifically on adapting drinking water and wastewater utilities, we chose to conduct interviews with Massachusetts water stakeholders to understand expert's opinions on what would be helpful when creating a plan.

We first interviewed water experts within MassDEP to collect ideas on how they can provide support to utilities, as a regulatory agency. Next, we interviewed directors of water associations to understand their influence over individual utilities. These associations are professional groups consisting of members in the water utility workforce, members of organizations outside the utilities who provide information to them, and other individuals who participate in the water utility community. We sought to determine how these associations could work with MassDEP to provide assistance to utilities. Finally, we interviewed our target audience, the utility operators and planners, to understand specifically what would be the most helpful when preparing for extreme climatic events. Through our interviews, we collected various findings that we have categorized as "needs" and "constraints" for planning.

Findings – Utilities' Needs for Adaptation Planning

- **Funding-related needs** such as money, people and equipment
- **Informational needs** such as climate change projections and education about how to handle the events brought on by climate change

- **The need for political support** such as approval from the local government to take action
- **The need for planning capacity** such as a team of engineers who look at long-term asset management

Findings – Constraints Associated With Creating an Adaptation Plan

- **The lack of communication** between the affected utilities, the associations and the regulatory agencies
- **Utilities' receptiveness to "climate change"** because not all people believe in climate change
- **Limited capacity of utilities to take on new challenges** such as the regulatory burden they face, the aging state of the infrastructure and the state of operating staff
- **Resources available to the MassDEP** such as their lack of funding, information and human resources

By using these needs and constraints as a set of criteria for gauging the recommendations that we received through our interviews, we were able to create a list to present to MassDEP that includes both short and long term recommendations.

Final Recommendations to MassDEP: Short-Term

These are the recommendations we feel would be most helpful for MassDEP to start implementing now. From our interviews, we have found that the resources are readily available for implementing measures and they might be effective at helping the utilities right now.

1. Develop consistent, effective messaging with other stakeholder groups such as the EPA, water associations such as NEIWPCC and the water utilities
2. Incorporate material about climate change effects in the Wastewater Operator Boot Camp being organized by NEIWPCC and the Board of Certification of Wastewater Treatment Plant Operators
3. Conduct a statewide assessment on water level rise to identify utilities that will be affected by a specific flood condition, river level rise or sea level rise due to the changing climate
4. Hold or sponsor presentations and conferences about the risks of climate change to utilities which could include specific actions utilities can take, as well as how the MassDEP is willing to help
5. Provide models and tools to the utility engineers and planners that demonstrate how the effects of climate change will affect the utility

6. Further develop and promote the Water/Wastewater Agency Response Network (WARN) to aid in storm preparedness
7. Evaluate and ensure emergency wetlands permits allow temporary equipment placement, such as levees
8. Promote communities to incorporate their water utility into the Incident Command System (ICS) planning
9. Evaluate new wastewater plant bypasses for construction in plants that currently do not have them, in order to save the plant from excess inflow during extreme storms
10. Suggest incorporating climate change resiliency into current design manuals for upgrading treatment plants, as well as for new treatment plants to be constructed
11. Promote incorporating the Supervisory Control And Data Acquisition (SCADA) system and training of it to operators if it is not already being done

Final Recommendations to MassDEP: Long-Term

These are the recommendations we feel would be most helpful for MassDEP to implement in the future. We recommend waiting to implement many of these methods because they require planning beforehand, there are not enough resources available or these measures will be more effective in the future than they would be now.

1. Expand water utilities' requirement to have and maintain an Emergency Response Plan (ERP)
2. Incentivize the State Revolving Fund (SRF) loan program for climate change adaptation plans
3. Require all utilities to have and maintain a climate change adaption plan

These recommendations were based on limited interviews and do not represent the views of all affected parties in Massachusetts. As the MassDEP moves ahead with helping water utilities, we recommend that the department remain open to further suggestions and recommendations on how to provide assistance. However, with these recommendations we hope the MassDEP can help the water utilities in Massachusetts become more resilient to the risks that climate change poses to their infrastructure in the near future.

Authorship

Abstract

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Executive Summary

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1.0 – Introduction

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1.0 – Introduction

Scientific evidence from the past century shows that the sea level is rising, the overall atmospheric temperature is increasing, and the intensity of storms is escalating (Alfsen et. al, 2007). The President of the United States, Barack Obama, has recognized the coming risks and spoke to the world about these issues at the United Nations Climate Change Summit in September, 2009. Obama expressed his concern for climate change and labeled it a critical threat that the world must address now. He stated, "The threat from climate change is serious, it is urgent, and it is growing." The purpose behind Obama's speech was to emphasize that no one can escape the impacts of climate change (Obama, 2009).

Changes in sea level rise, average temperature and storm intensity pose a significant threat to drinking water and wastewater utilities worldwide. These systems provide clean water to the populace and treat the used, dirty water for safe disposal. The Intergovernmental Panel on Climate Change has stated that a lack of available water and a higher water demand resulting from population growth are variables that "pose a tremendous challenge to providing satisfactory water services" (Alfsen et. al, 2007, p. 69). Due to threats posed by climate change, water utilities face not being able to adequately provide their services to the public in the future.

A mounting problem of preparing water utilities for the risks of climate change has spurred recent interest in adapting water facilities for these changes. Communities such as King County, Washington and Keene, New Hampshire have recognized the risks and taken action for adapting their key infrastructures for climate change (Corell et al, 2007). The Connecticut Department of Environmental Protection has recently analyzed how its wastewater infrastructure will be affected by sea level rise and released a report on the areas affected (Fisk, 2007).

In May, 2009, the Massachusetts Executive Office of Energy and Environmental Affairs created the Climate Change Adaptation Advisory Committee (CCAAC). The CCAAC's main focus is to make recommendations on strategies for adapting to climate change (CCAAC, 2010). The Massachusetts Department of Environmental Protection (MassDEP) has worked alongside the CCAAC in identifying the need for drinking water and wastewater utilities within the commonwealth to start adapting for climate change. However, MassDEP is unsure how they can support the water utilities with adaptation measures.

The goal of this project was to provide recommendations to MassDEP on how they can support Massachusetts drinking water and wastewater utilities in adapting to climate change. Before creating recommendations, we first researched how the climate is changing and how it will affect water utilities. We also looked into past and present examples of climate adaptation plans. Next, we interviewed groups of people from MassDEP, water associations, and water utilities to come up with recommendations and receive some feedback on how helpful they might be. Finally, we analyzed responses to the recommendations and presented a

recommended action plan for the MassDEP to support the water utilities with climate change adaptation.

2.0 – Background

The Massachusetts Department of Environmental Protection (MassDEP) has recognized the need to adapt drinking water and wastewater utilities to the harsh effects climate change poses. MassDEP asked us to create a list of recommendations detailing the ways in which they can better prepare these utilities for a changing climate. In this chapter, we detail the ways in which the climate is changing and how these changes are predicted to impact drinking water and wastewater utilities. From there, we describe how climate change adaptation planning is being accomplished in other communities around the United States, and also MassDEP's role as a regulatory agency in the commonwealth.

2.1 – How the Climate Is Changing

Over the course of the last 30 years data has shown that global temperatures have risen steadily. Temperature has had a catalyzing effect on other components of the water table including glacial mass decrease, sea level rise, and greater storm intensity (Alfsen et. al, 2007). Climate scientists believe this phenomenon to be a result of climate change, the shift of long-term patterns in weather and temperature. In this section we describe these changes and their effects, showing their past trends and future projections on hydrology.

Projections calculating air, land, and sea surface temperature have improved dramatically due to updates made by the Climatic Research Unit (CRU) on recent temperature record revisions dating back to 1850 (Brohan et. al, 2006). Data collected by the CRU has helped associations such as the NOAA model the projections of climate change with less error. Projections from one such model are shown in *Figure 1*, which displays the global mean temperature over land and the ocean for the last 130 years. As mentioned above, the last 30 years have shown the most rapid increase of temperature contributing a 0.6º degree Celsius (1.1º F) increase to the overall 1º Celsius (1.8º F) increase that has taken place over the last century.

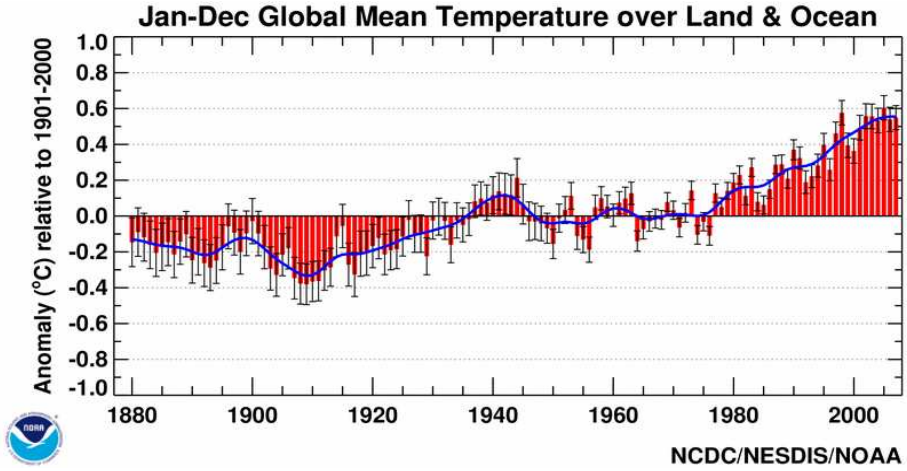

Figure 1: Global Mean Temperature of Land and Water Since 1880

Image Courtesy of U.S. National Oceanic and Atmospheric Administration (NOAA)

The National Association of Clean Water Agencies (NAWCA) has projected that the temperature in the Northeastern United States will rise approximately 4-6º Fahrenheit over the next 40 years (NACWA, 2009). This temperature change would be significant enough to affect water mass globally, potentially melting away great volumes of snow and ice (Mann, Bradley, and Hughes. 1999). Data collected by the NOAA-NCDC was used to create *Figure 2*, which shows the changes in the average annual temperature in the Northeast region over the 20th century. This increase in temperature was the most severe along the east coast of Massachusetts with some areas south of Boston showing an increase greater than 5º Fahrenheit.

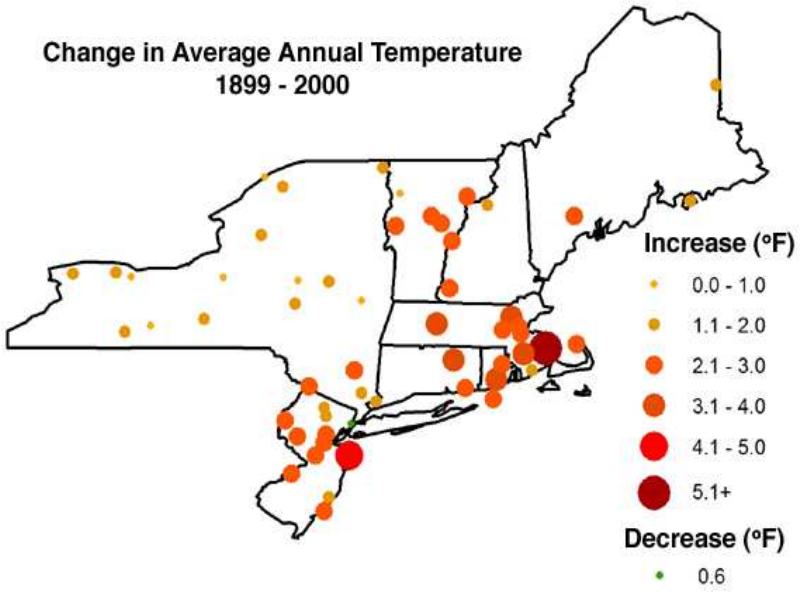

Figure 2: Change in Average Annual Temperature: 1899-2000
Image Courtesy of U.S. National Oceanic and Atmospheric Administration (NOAA)

Due to the widespread temperature increase, glaciers, ice caps, and snow located in the Northern Hemisphere have shown a consistent decrease in volume over the past century. Satellite images have shown that between 1960 and 1990 the average decrease in snow mass was 0.37 +/- 0.16 mm/yr. However, between 1990 and 2003 the decrease in snow mass was 0.77 mm/yr, showing a direct link to an increasing temperature (Alfsen et. al, 2007). *Figure 3* shows the decrease in the mass balance of snow totaling a loss of 12 meters of water equivalent mass over the past 30 years.

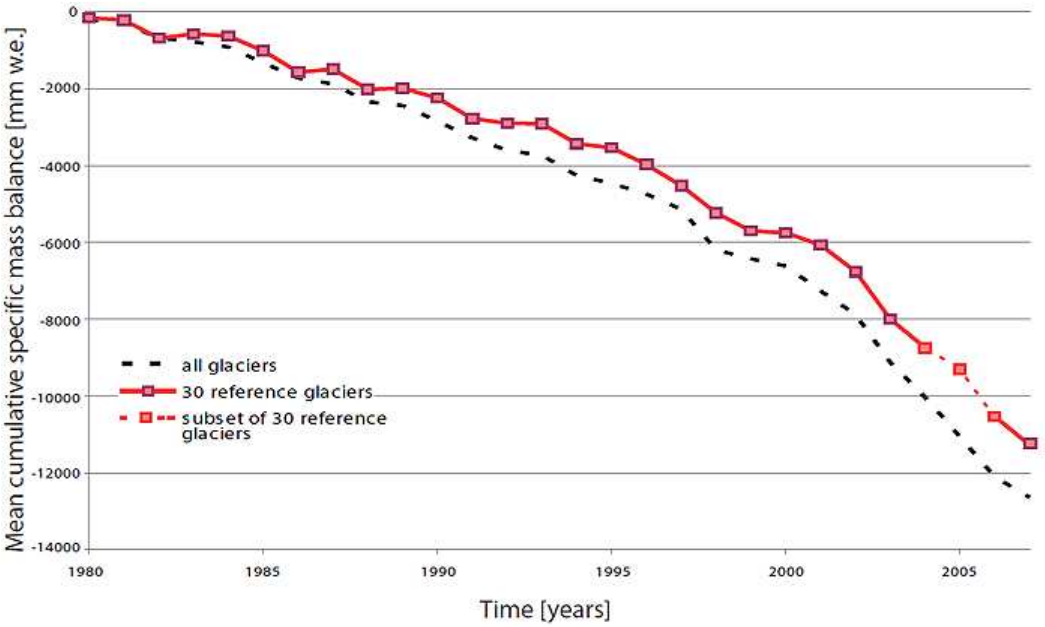

Figure 3: Decrease in Mass Balance of Snow and Ice Over the Last 30 Years
Image Courtesy of World Glacier Monitoring Service (WGMS)

Sea level rise can be directly attributed to the melting of glaciers and ice sheets. Coastal areas and wetlands in the southern United States have already begun to erode and become submerged due to the rising sea level. Scientists measured a 1.8 mm/yr increase in global sea level rise between 1961 and 1990. Between 1993 and 2003, the average increase of sea level rise was 3.1 mm/yr. However, sea level rise is not the same in every location. *Figure 4* shows the sea level rise statistics for Boston, Massachusetts over the last century, as recorded by NOAA. The mean sea level trend for the city is shown to be 2.63 mm/year and has a 5% margin of error.

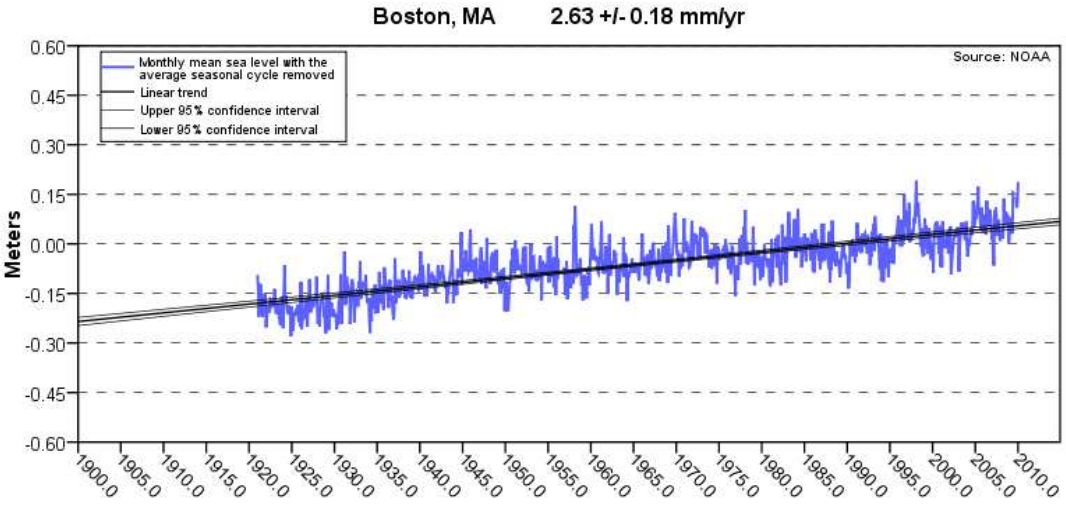

Figure 4: Mean Sea Level Trend Increase in Boston, MA over the 20th Century
Image Courtesy of U.S. National Oceanic and Atmospheric Administration (NOAA)

Modeling for sea level rise based on past trends has led climate scientists to predict that the sea level around Boston will rise between 1.5 to 2 feet by the year 2100 (NACWA, 2009). *Figure 5* is a detailed map of Massachusetts showing the elevation of coastal areas, with respect to sea level. Projections from the NOAA can be used to predict which areas will be affected by 1.5 meters of sea level rise. These areas are shown in red on the image. Areas colored in bright blue reflect the places that are within 1.5 to 3.5 meters above sea level.

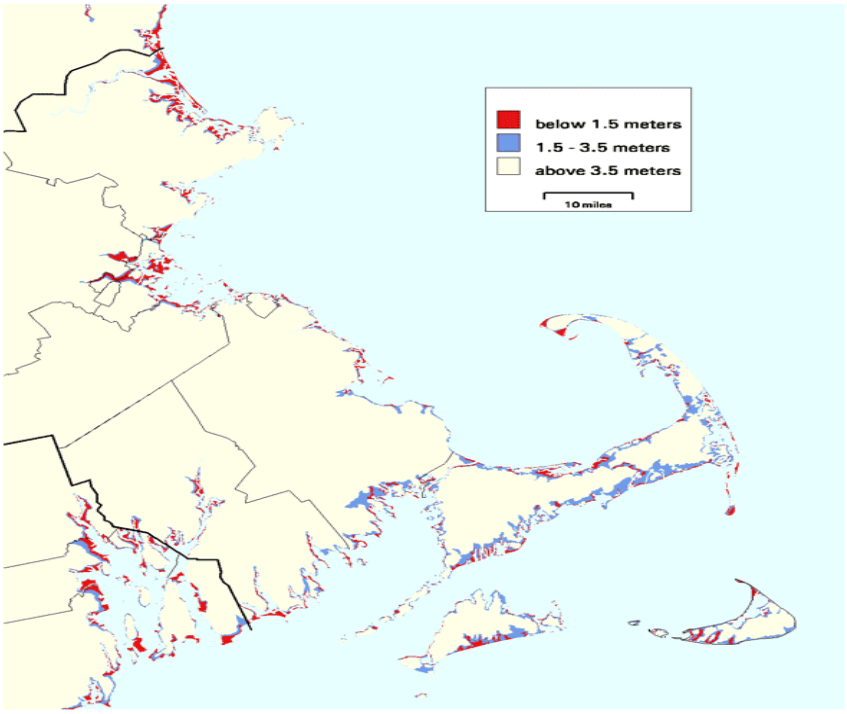

Figure 5: Areas Vulnerable to Sea Level Rise in Massachusetts
Image Courtesy of U.S. National Oceanic and Atmospheric Administration (NOAA)

As a result of both temperature and sea level rise, climate change will increase storm intensity. Data taken in the North American region shows that a greater amount of precipitation is consistent with higher temperatures (Madden and Williams, 1978). Due to the increase in surface temperature, the amount of water vapor increased by 5% during the 20th century. More water vapor in the air leads to more precipitation, which will make the severity of storms closer to tropical-like scenarios (Alfsen et. al, 2007). *Figure 6* displays the Northeast region with data corresponding to the change in annual precipitation during the 20th century. Areas next to large bodies of water, such as along the Atlantic Coast and near the Great Lakes, have shown a greater increase in precipitation than inland areas as shown in the figure. Past data has shown that the city of Boston, for example, has experienced about an 8.1 inch increase in annual precipitation levels since 1900.

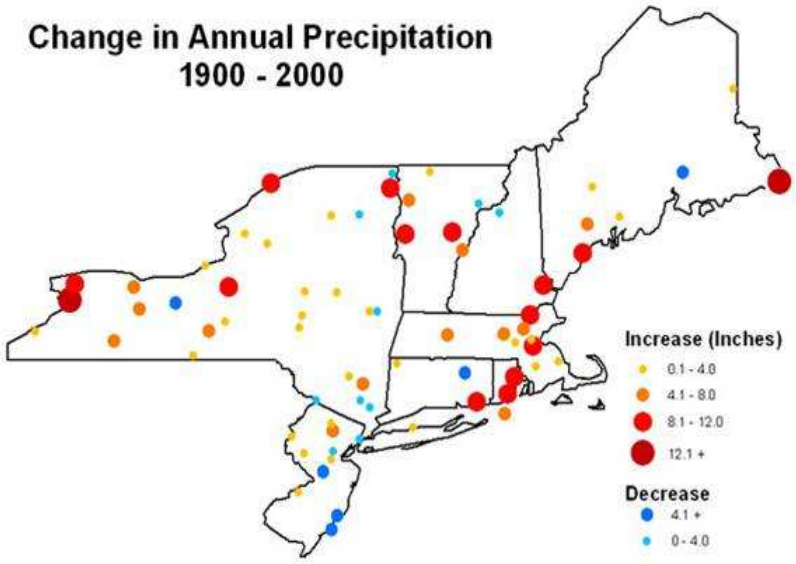

Figure 6: Change in Annual Precipitation: 1900-2000
Image Courtesy of U.S. National Oceanic and Atmospheric Administration (NOAA)

2.2 – Effects of Climate Change on Water Infrastructures

In order to understand how municipal drinking water, wastewater and stormwater infrastructures may be affected by climate change, it is first necessary to understand the inner-workings of the systems. These infrastructures are vital to community members by providing them with clean drinking water, a way for treating dirty water, and a method to return water into receiving waters, so it can be used again. An overview of how each infrastructure will be affected by the changing climate is described in this chapter.

2.2.1 – Drinking Water Infrastructure

Municipal drinking water infrastructure is relied on by many Massachusetts residents as a means to collect, treat and disperse water to homes and businesses. Drinking water must be treated according to the Safe Drinking Water Act of 1974 to ensure it is safe for all customers before consumption (EPA, 2010).

If predictions are correct that storms will increase in intensity and temperatures will rise, there will be more water entering lakes and rivers, and therefore reservoirs. This increase will occur earlier in the year because the snow will melt more quickly from the increase in average temperature. The increase in snow melt could potentially pose a problem for reservoirs' storage needs, which would have to be increased to allow for a greater influx of water (NACWA, 2009). During the 50 year storm that occurred in mid-March 2010, over 10 inches of rain fell on central Massachusetts (Andersen & Schworm, 2010). The Wachusett Reservoir in Clinton, MA reached capacity, and crested over the spillway. Nearly two billion gallons of water per day was being dumped over the spillway, thus flooding many riverside

properties downstream (MWRA, 2010). *Figures 7 and 8* show the effects of flooding on a riverside property during and after this spillway overflow. This type of event might be more likely to occur in the future as storms increase in intensity.

Figure 7: Field in Clinton, MA Prior to Wachusett Reservoir Spillway Overflow
Photo Courtesy of John Flannagan, Jr.

Figure 8: Field in Clinton, MA After Wachusett Reservoir Spillway Overflow in March, 2010
Photo Courtesy of John Flannagan, Jr.

Once water has been collected in a reservoir, it is ready for transmission to a treatment plant. *Figure 9* provides an overview of the different steps that are involved at a typical drinking water treatment facility once the water has been piped in.

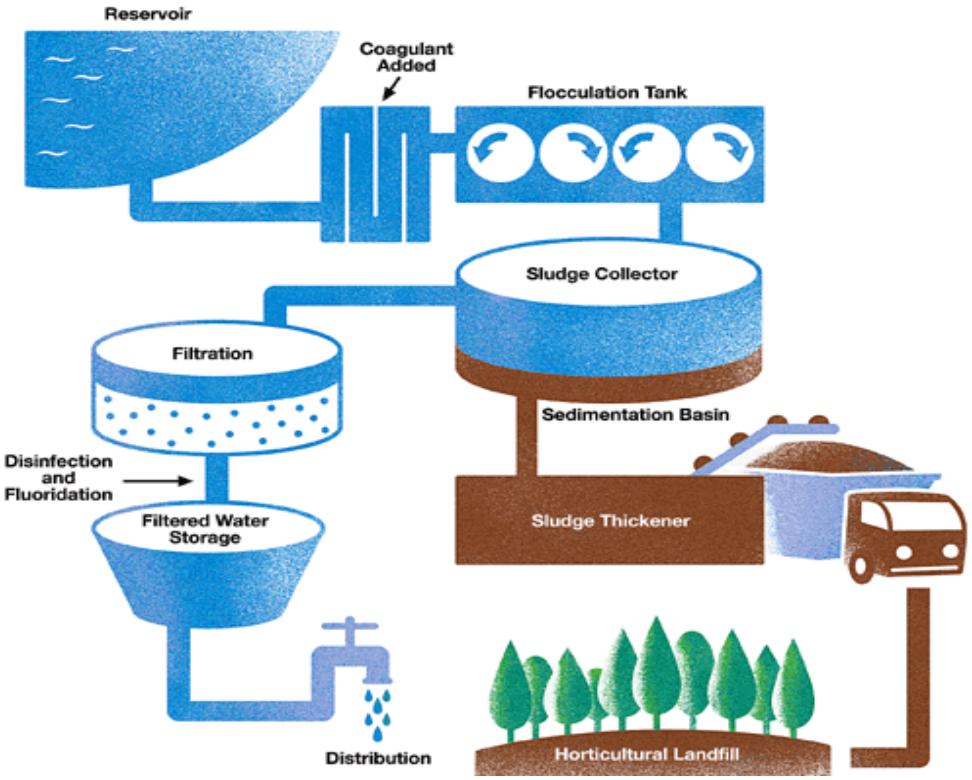

Figure 9: Drinking Water Treatment Process
Image Courtesy of South Australian Water Corporation

Once water enters the treatment plant, a coagulant is mixed in. The water is then sent into a flocculation tank where solids coagulate and sink to the bottom in a sludge collector, as shown in *Figure 9.* From there, the water can be filtered in beds of sand and gravel where smaller particles can be strained out. Then the water can be disinfected with chlorine or ultraviolet radiation to help kill of any remaining harmful bacteria (MWRA, 2009). With an increase in temperature from climate change, water temperatures will also rise. With this increase, harmful bacteria will have a more hospitable environment to grow in. Longer and more intense cleaning procedures will be needed to ensure the water meets quality standards of the Safe Drinking Water Act (EPA, 2010).

2.2.2 – Wastewater Infrastructure

Once water enters a home or business and is used in a plumbing fixture such as a toilet or sink, it is considered wastewater. In order for wastewater to be treated and released back into its natural system, it must be sent through a system of sewers, pipes and pumps before it

arrives at the treatment plant (Grigg, 2003, pg. 19). Wastewater treatment plants are very different from drinking water treatment plants because they have different components needed to remove larger solid waste particles, and they require a different type of location to operate efficiently.

There are two types of sewer systems that transport wastewater from businesses and residences to a treatment plant. *Separate* sewer systems transport only wastewater to the plant. *Combined* sewer systems operate similar to separate sewer systems by transporting wastewater, but they also transmit stormwater in the same pipes. Stormwater is collected in storm drains from roof and road runoff. The storm drains connect on to main sewer lines, thus mixing the two waters together (MWRA, 2009).

As shown in *Figure 10*, there can be a dam inside a combined sewer line. This is part of the combined sewer overflow (CSO). In dry conditions, the system operates efficiently, because there is not enough water to reach the top of the dam, thus allowing all of the combined water to flow to the treatment plant. However, in periods of high precipitation there can be up to five times the amount of water running through the system (MWRA, 2009).

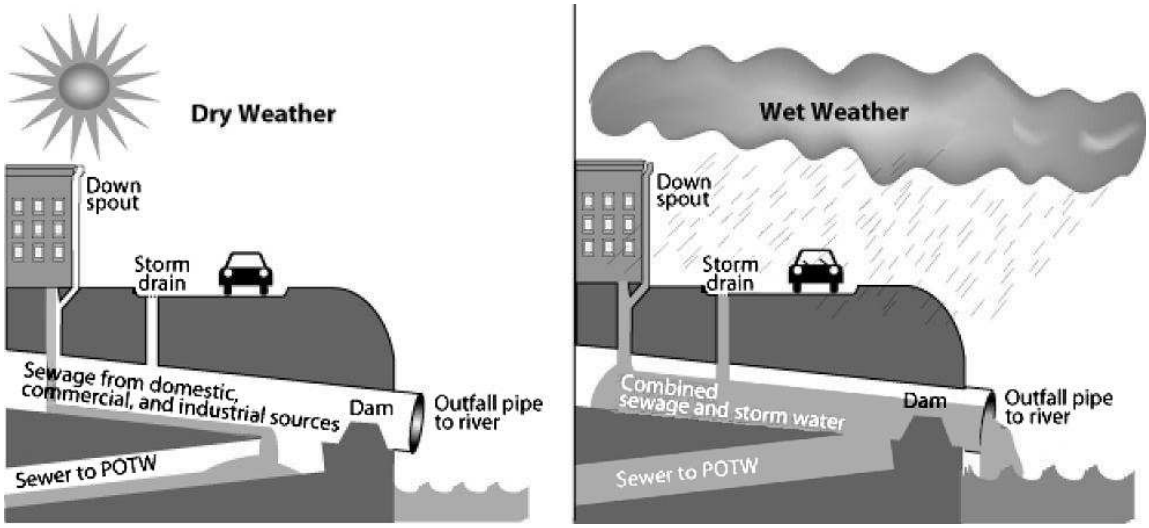

Figure 10: Combined Sewer Systems: Dry vs. Wet Weather Conditions
Image Courtesy of U.S. Environmental Protection Agency (EPA)

Combined sewer overflows act as breathers or relief points, to prevent the backup of wastewater in residences and businesses. By doing so, the excess water flows over the dam and is sent into receiving waters, but at the expense of the receiving water's quality (MWRA, 2009). As storms increase in intensity, there will be more wastewater polluting rivers and oceans.

When possible, both separate sewer systems and combined sewer systems are completely gravity fed which is why treatment plants tend to lie at the lowest elevation possible. However, sometimes gravity cannot do the work alone because of the lay of the land. A lift station or pump can be used to help facilitate this process and move the wastewater up a

hill or to a higher elevation in such a situation (MWRA, 2009). Wastewater treatment plants also tend to lie along rivers so that cleaned water can be released efficiently. With a predicted increase in storm intensity, rivers will rise and increase in size, thus potentially put riverside treatment plants at a higher risk from flooding. Low lying electrical systems and pumps could also be at risk from water damage.

As wastewater arrives at the plant, it undergoes multiple phases of treatment in order to meet water quality standards, before being released back into receiving waters. These phases are categorized as primary, secondary and tertiary treatment, each with increasing levels of processing to the wastewater. *Figure 11* shows the different phases that wastewater goes through at a typical treatment plant.

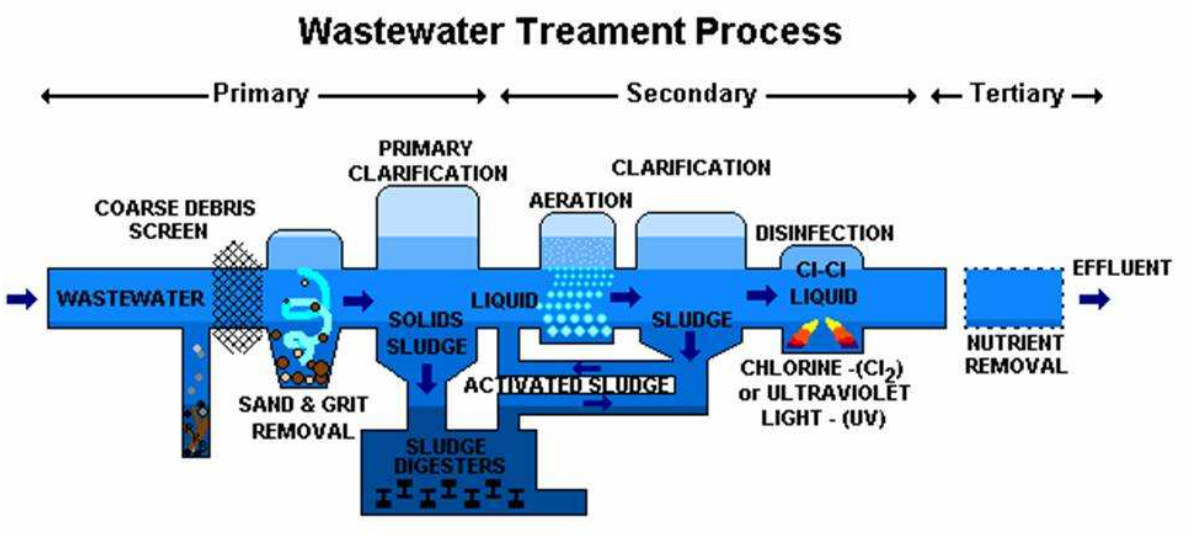

Figure 11: Typical Wastewater Treatment Process
Image Courtesy of South Australian Water Corporation

With a rise in sea level, low-lying wastewater treatment plants could face the dangers of salt water intrusion and flooding. Salt water could potentially kill off helpful bacteria needed to clean the water. This could affect the treatment levels necessary to ensure the water is properly treated before it is released (MWRA, 2009).

2.2.3 – Separated Stormwater Infrastructure

Separated stormwater infrastructure is similar to wastewater infrastructure by involving a gravity fed system of pipes to transport the water to rivers and other receiving waters. These systems often have large diameter pipes to help move the more water rapidly, thus negating the flooding effects that severe storms may bring. Stormwater is brought into pipes from various places such as storm drains, gutters and roof runoff (Grigg, 2003, pgs. 24-27).

Because sidewalks, driveways and many pavement types are impermeable, precipitation simply cannot seep into the ground in these locations, as it would on a grass lawn. Stormwater running off these impermeable surfaces is fed into a storm drain located on the side of a road. There are typically many storm drains installed on each side of a street to help to minimize backups and flooding (EPA, 2003).

With an increase in storm intensity, permeable surfaces such as soil could quickly become overwhelmed by excess amounts of water. The soil's ability to absorb water would be drastically reduced and precipitation would not be able to seep into the ground at these locations. Since water always tries to find the path of least resistance, it will attempt to flow into storm drains alongside the road if the ground is completely saturated. These storm drains will become increasingly overstrained as precipitation becomes more intense and they might not be able to handle the excess water entering the system, especially if the pipes are old. If some storm drains become clogged with leaves or debris, then stormwater will start pooling and flooding the surrounding area (EPA, 2003).

Stormwater remains raw and untreated as it is collected and ultimately released into receiving waters. Therefore any pollution in the system is also dumped into rivers and oceans. Separated stormwater infrastructure acts as a quick way to remove as much water as possible, but does nothing to filter out debris from entering the environment (EPA, 2003). As storms increase in intensity, more runoff and contamination will enter receiving waters through stormwater systems.

2.2.4 – Summary

Water infrastructures will be negatively affected by the changing climate in the years to come. A quick overview of what will be affected by each climactic change is shown in *Table 2*.

Table 2: Climate Change Impacts and Needed Actions

Climactic Change	Impact on Infrastructure	Action Needed
Increase in temperature	Earlier snow melt going into reservoirs	Increase reservoirs capacities
	Greater bacteria levels in drinking water	Treat water with more intense procedures
Sea Level Rise	Flooding of plant	Raise up vulnerable components
	Salt water intrusion	Treat water with more intense procedures
Increase in storm intensity	Flooding or inundation of plant	Raise up or upgrade vulnerable components
	Combined sewers will overflow	Separate combined sewer systems
	Stormwater drains become overstressed	Install larger pipes and drains

2.3 – Approaches to Climate Change Adaptation Planning

The importance of keeping our water infrastructure protected is obviously great. Without properly functioning drinking and wastewater systems the health of consumers is in great jeopardy (Gilmore, 2000). Many utilities in the state of Massachusetts will find it necessary to create a plan to protect themselves from the changing climate.

There are many examples of communities that have recognized the coming threat that climate change poses. Some of these communities have already created their own climate adaptation plans and some have even begun acting on their plans (CRCC, 2007). In each of these plans, the communities outline clear risks to their local water utilities. By reviewing material aimed specifically at helping utilities come up with an adaptation plan, we found that a very similar process was being suggested by most resources (Cromwell et al, 2007). In this section we have outlined the community-wide adaptation plans as well as utility adaptation planning needs and draw parallels between the two.

2.3.1 – Community Climate Change Adaptation Planning

Below, we review community-wide approaches to adaptation planning. As mentioned, the planning processes that we have reviewed all follow similar guidelines. These guidelines are outlined in many guidebooks created for wide-spread distribution and are available from ICLEI – Local Governments for Sustainability, the Water Utility Climate Alliance (WUCA) and the Pew Charitable Trusts.

Figure 12 shows a typical planning process for a community as suggested in ICLEI's toolkit for adaptation planning. The first step in this process is establishing the context of the plan. This step primarily consists of creating a planning committee to handle the planning process. A committee's size is determined by the needs of the given community. A smaller community's committee, such as that of Keene, New Hampshire, which has a population of about 23,000, consists of only a collection of city officials and researchers with the relevant academic backgrounds (CRCC, 2007). Miami-Dade County in Florida has a population of over two million and their committee consists of several sub-committees for research, evaluation of specific municipalities and general administration (Miami-Dade County Climate Change Advisory Task Force [CCATF], 2008).

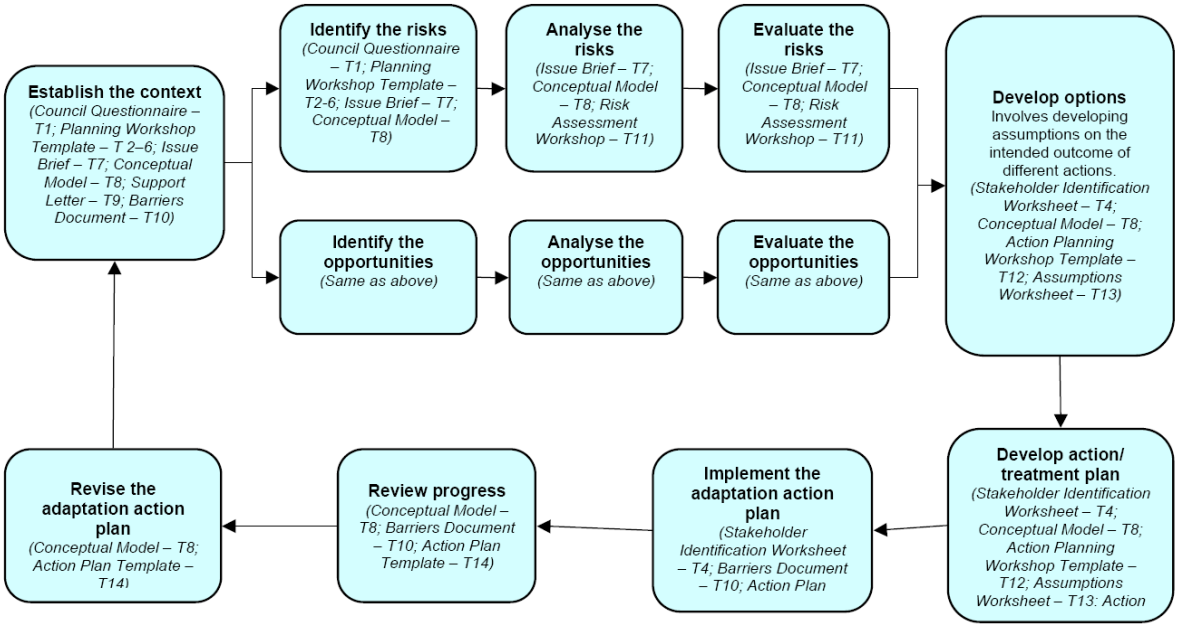

Figure 12: Adaptation Management Process
Image Courtesy of ICLEI Oceania

The committee's goal is first to identify how the climate is going to change in their specific community. There can be multiple projects to select from in each location. One of the committee's challenges will be to determine which of these projections is most reliable and will best pertain to their specific location. Miami-Dade County is predicting a 3-5 foot sea level rise by the end of the century (Miami-Dade CCATF, 2008). New York City is predicting higher temperatures by 4-7 degrees, increased annual precipitation by 5-10% and a rise in sea level by 1-2 feet by 2080 (Horton and O'Grady, 2009). Identifying the severity of the changes strongly influences planning for climate change.

Once the committee chooses a climate change prediction that they believe should be planned for, the community's next task is identifying the risks those change imposes on the town and its structures. The Intergovernmental Panel on Climate Change's (IPCC) technical reports are used as a guideline for community researchers for where to start looking at potential impacts. Keene uses the IPCC report to identify a wide range of areas that will be impacted, which they separated into three distinct categories: built environment including buildings, water infrastructure and energy systems, natural environment including agriculture, groundwater and wetlands and the social environment such as public health, economy and emergency services (CRCC, 2007). Each of these areas will be impacted differently and each requires its own research.

After planners identify the areas of concern and narrow down the specific vulnerabilities to a system, the next step is to create plans for protection against climate change. Very few communities have reached this stage since many are still in the identification stage of climate

change adaptation planning. Keene is one example of a town that has progressed to creating plans to solidify their water infrastructure against climate change. For the built, natural and social environments, the Town of Keene has identified specific targets of change. Examples include preventing development in the predicted 200-year floodplain, encouraging higher pitched roofs in preparation for snow stacking and passing codes to require green building standards to prevent further climate change. Specifically for the stormwater infrastructure, Keene has created specific targets of creating a regional management plan and having it endorsed or adopted by all municipalities by 2015, identifying areas that require increased resources to hold/divert the water, and including the stormwater system in the city-wide reassessment to replace failing or antiquated infrastructure (CRCC, 2007). The plan has very specific targets that allow the city to adapt to climate change impacts before they pose a higher risk.

The next step in the planning process is to begin implementation of the specific targets identified previously. King County in Washington, which contains Seattle, is one of the few communities currently in the implementation stage. In 2008, they conducted a training program for coastal managers and planners on climate change planning, continued progress rebuilding the regional levee system, and initiated a water reclamation plan. (King County, 2009) King County has released annual reports on their progress to help them assess how their overall plan is going as well as to show their population that they are making changes. King County has served as an example to help ICLEI its their own broad-range guidebook designed for all municipalities (Snover et al, 2007). A study done by the Heinz Center concludes that ICLEI's guidebook is one of the best recent climate change planning guidebooks for local governments (Corell et al, 2007).

2.3.2 – The Needs in Water Utility Climate Change Adaptation Planning

In the previous section, we presented material that focuses on helping communities plan for climate change, but there is a distinction between a community-wide plan and a plan for water utilities. A community climate adaptation plan sets goals for protecting the water utilities, such as building levees around treatment plants, but it does not specify how the utilities will achieve those goals (King County, 2009). Drinking water and wastewater utilities have a specific set of needs defined by their current planning team. We have reviewed material aimed at helping those teams with adapting to climate change.

A major requirement for a utility looking into climate change adaptation is specific, relevant information pertaining to how the climate is changing. General information on the changing climate in the region is not adequate for utility planning teams to make informed decisions. A survey conducted by Tribbia and Moser in 2008 shows the information coastal planners consider being the most beneficial for adaptation planning. Their survey suggests that generally planners will find specific projections and their effects pertaining to climate change

more useful than a general forecast of what will happen in the near future (Tribbia and Moser, 2008).

According to Tribbia and Moser's survey, one of the most helpful types of information for a planning team to look at is information on how to evaluate the vulnerability of the utility's assets (Tribbia and Moser, 2008). This kind of information describes how changes in the climate will affect specific components of a water system. For example, collaboration between the National Association of Clean Water Agencies (NACWA) and the Association of Metropolitan Water Agencies (AMWA) identified specific vulnerabilities to drinking water and wastewater systems. These vulnerabilities include reduced precipitation runoff leading to a decreased water supply, sea level rise contributing to flooding of treatment facilities and changes in temperature affecting the water treatment process. With this information, the planning team in a utility can then look at what components in their system are at risk and assess how they will be affected (NACWA, 2009).

Another important type of information a planning team can use in adaptation planning outlined in Tribbia and Moser's survey is specific projections on how the climate will change in their area (Tribbia and Moser, 2008). The difference between projections made by a community and projections made over broader regions such as those in the IPCC technical reports is the accuracy that they have. For a community-wide planning effort, a committee should select specific projections on what should be expected for climate change in their area as discussed above. The specific projections can then go to the utility planners so that they accurately evaluate their vulnerabilities. Projections made over a broad region could have a wide range of values within that region that get averaged out of the final projection. An example of such an averaging error can be seen from the difference in sea level rises around the world. *Figure 13* shows the trends of sea level rises during the past 18 years across the globe. Notice that the sea level trend can differ significantly in locations, some places even showing sea level fall. Differences between trends can lead to generalizations that will not be accurate enough to provide a robust prediction, even within small areas. A utility without specific projections for its community will be forced to rely on generalized, public means of collecting projections such as information available from the IPCC (Snover et al, 2007).

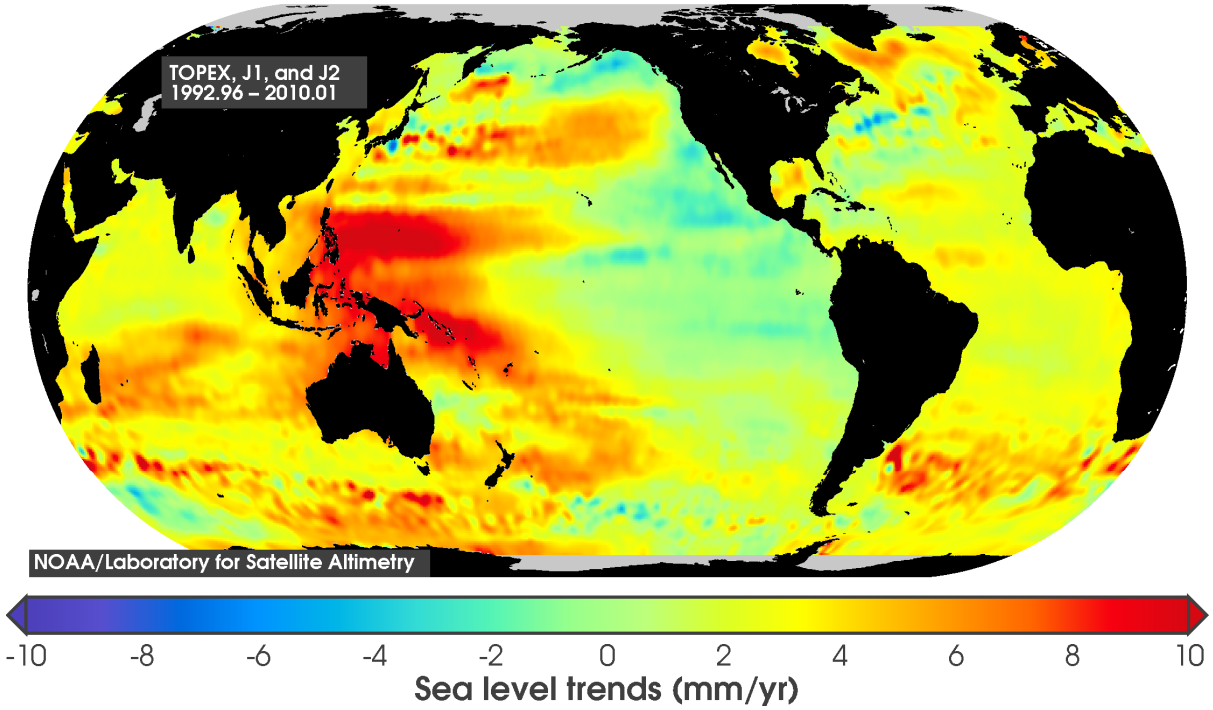

Figure 13: Global Sea Level Trends from 1992 to 2010
Image Courtesy of U.S. National Oceanic and Atmospheric Administration (NOAA)

Even without specific projections, a utility can plan for adaptation with preliminary data gathering. The Connecticut Department of Environmental Protection (CTDEP) has released a specific study of wastewater infrastructure and how it would be affected by climate change. This study surveyed a sample of towns and compiled a list indicating how much of their sewer system would be submerged in the event of sea level rise. The study does not assume that the sea level will rise by a predetermined amount, but instead evaluates the amount of pipeline submerged with a rise of one, two and three meters. The study also includes pumping stations and treatment facilities as potential risks (Fisk, 2007). With general studies like this, communities can prepare for multiple climate change situations. After a study like this is done, communities will know what levels of climate change effects, such as sea level rise or intense storms, they can handle.

2.3.3 – The Difficulties of Adaptation Planning

There are several challenges associated with long term planning for drinking water and wastewater utilities. Availability of financial, technological and human resources as well as the capacity to conduct studies and plan for future events are all factors which will have a great impact on a planning process. A utility with limited funding will most likely not choose to spend it on upgrading a water system that currently is operating without any concerns. Similarly, a utility lacking the capacity to assess the impacts of climate change may not be able to make a decision. An additional hurdle for a utility looking to plan for climate change is the attitude of

community it supplies. Especially for publicly owned utilities, a community skeptical of the idea of climate change in general may not accept the risks that it poses to the water infrastructure and may tend to oppose any planning attempts that it has control over (Anguelovski et al, 2009).

A major barrier that was identified for adaptation planning by Susan Moser in 2009 is a lack of leadership. In her California-based study, they found that plant operators are very unlikely to take on the responsibility of adapting to climate change on their own. However, leadership at higher levels of authority over individual utilities influences the utilities themselves to start looking into planning for climate change (Moser, 2009). To date, the influence from government agencies on climate change has had more of a focus on mitigation, such as use of more sustainable energy sources, than on adapting to the effects (Moser, 2009).

The unpredictability of the climate is also a major challenge in adaptation planning. We have already discussed many climate projections, predicting specific changes in weather averages. However, these projections can vary depending on what variables and past records the researchers used (Brohan et. al, 2006). A study in uncertainty measurements suggests that selecting one single projection may not be the best strategy for a community to implement. Using an array of projections, and gathering what would be a best and worst case type of scenario may be most useful for planners in designing a climate proof system (Brohan et al, 2006). While this may be the most effective way to plan for climate change, it also complicates the planner's job.

Another area of concern is when a water utility should start planning to adapt to climate change. The urgency to begin planning for climate change can vary from utility to utility. Those that have already begun a planning process, such as Miami-Dade's, are generally utilities that have had a concern with factors contributed to climate change in the past (Miami-Dade CCATF, 2008).

The length of time it takes to assess, create a plan and physically adapt an entire system adds to the concern of when a utility must begin looking at climate change. Every aspect of the infrastructure would need to be analyzed to determine its resiliency to a change in climate. These aspects include reservoirs, transmission lines, access holes, pump stations and treatment plants (Grigg, 2003). The system's elevation, flow capacity and age would all be factors to consider. The process has already proven extremely time-consuming for some places. For example, Keene, NH came out with their first climate change adaptation report in 2004 and is still in the process of revising and implementing a plan 6 years later (CRCC, 2007).

2.4 – How the MassDEP is Dealing With the Effects of Climate Change

The Massachusetts Department of Environmental Protection (MassDEP), according to its mission statement, "is the state agency responsible for ensuring clean air and water, the safe management of toxics and hazards, the recycling of solid and hazardous wastes, the timely

cleanup of hazardous waste sites and spills, and the preservation of wetlands and coastal resources" (MassDEP). MassDEP sees to it that water quality specifications of drinking water and wastewater that are set by the government and state are maintained by every water utility. These standards can be found in full on the MassDEP website. MassDEP regulates and enforces water standards by reviewing every treatment center's submitted water sample, making impromptu physical inspections, and distributing fines when a utility is out of compliance. Along with policing state utilities, MassDEP also holds responsibility in advising these utilities on current issues such as new technologies, new regulations or climate change.

MassDEP has formed a committee which will advise the commonwealth on ways to mitigate the adverse impacts it will face due to climate change, called the Climate Change Adaptation Advisory Committee (CCAAC). The CCAAC's responsibility is to advise the Executive Office of Environmental Affairs on the best ways to adjust to climate change (MassDEP). A report will be presented to the Legislature in the late spring of 2010 on the committee's findings. These findings are expected to include adaptation strategies on natural resources and habitats, local economy, key infrastructure, human health, coastal zones and oceans (MassDEP). The creation of this committee suggests that the Massachusetts Department of Environmental Protection is concerned with different aspects of climate change. It also shows the responsibility they have taken in helping the state prepare for the future.

A step that was identified in this committee's process is to create useful and dependable climate projection maps for regions in Massachusetts. Types of climate prediction maps could include sea level rise with new coastlines, different flood plane scenarios, and temperature changes. MassDEP believes that for utilities to accept the importance of adapting for climate change, these maps will be a key tool. The GIS map specialist at MassDEP is currently conducting research and creating a tool for these utilities to use. He is working with the Federal Emergency Management Agency (FEMA) and their flood information in his work.

Our mission is to assist the MassDEP with its climate change adaptation efforts. During our seven weeks of full time work in Boston, our goal was to provide MassDEP and its Climate Change Adaptation Advisory Committee with information on ways in which the state can support drinking water and wastewater utilities in adapting to climate change.

3.0 – Research Methods

The goal of our project was to provide recommendations to the Massachusetts Department of Environmental Protection on how to support Massachusetts drinking water and wastewater utilities with adapting to climate change effects. To achieve our goal, we divided our work into four objectives. Our first three objectives focused on collecting information and opinions about what water utilities need in order to plan. We interviewed individuals from three stakeholder groups:

- MassDEP employees with expertise in broad range planning needs;
- Directors of regional water associations with expertise in more specific planning needs; and
- Operators and planners within water utilities to understand direct needs.

Our final objective consisted of compiling and analyzing all of the recommendations from each of the stakeholder groups, and creating a final list of recommendations to provide to the MassDEP. In this chapter, we will describe how we accomplished each of these objectives.

Objective 1: Gather Opinions on Assistance Needs from MassDEP Experts

We first interviewed MassDEP employees with considerable experience in drinking water and wastewater regulations in order to understand the broad range needs for planning. The following research questions guided our data collection efforts:

- *What are the primary threats posed by climate change to drinking and wastewater facilities?*
- *What is the urgency, if any, to begin planning for these impacts?*
- *What possible obstacles are there to creating and implementing a plan to protect water systems from climate change?*
- *What ways can MassDEP facilitate the planning process?*

Beginning with MassDEP was a logical choice since it is the broad-range, state regulatory agency that oversees all activities of the individual water utilities. MassDEP personnel had in-depth information on the policies and regulations that water utilities must follow. Understanding the influence MassDEP has over the regulations and how it could contribute to future plans helped us recognize the limitations we would have to consider when presenting our final recommendations.

Our contacts at MassDEP created a list of directors and overseers to interview initially. We decided that performing face to face interviews would be the most logical choice because a

lot of the personnel inside MassDEP were readily available to talk with us. Sometimes we interviewed multiple personnel at once, so they could bounce ideas off of one another, and help spark each other's memory. We established interviews with the directors from both drinking and wastewater programs, including the northeast Massachusetts regional director. We also sough interviews with people from the departments of Security and Emergency Response, the State Revolving Fund (SRF), and GIS (Geographic Information System) modeling. This group of contacts had information regarding state emergency situations, the measures currently in place, and areas to look for financial help.

To contact the potential interviewees, we first sent out an email introducing ourselves, our project and what information we hoped to gain from the interview. We informed them of our requirement of informed consent, either written or verbal, and the promise of confidentiality upon request. We also informed them of our desire to record the interview but emphasized that it was a decision to be made by them. This form letter is included in *Appendix B*.

We conducted interviews with nine MassDEP officials. During our interviews, our goal was to answer the research questions outlined above. To have them answered in detail, we formulated a set of specific questions that we used as a guide during the interview. This list of questions can be found in *Appendix A.* We did not strictly adhere to following the questions as it often became beneficial to explore relevant tangents during the interview. Doing so allowed us to learn of concepts and ideas that helped us form recommendations that otherwise would have been overlooked by our planned questions.

After we conducted each interview, we compiled what we learned into a bulleted summary. As a team, we reviewed each of the answers we received and summarized what we thought the key points were. We sent the summaries to the interviewees and asked them to review and clarify to ensure that there was mutual understanding between all parties.

Objective 2: Gather Opinions on Assistance Needs from Water Associations

We chose to interview directors and managers of state and regional water associations within Massachusetts next to understand their influence over utilities. A water association is a professional group consisting of members in the water utility workforce, members of organizations outside the utilities who provide information to them, and other individuals who participate in the water utility community (MWWA, 2009). In this section, we present how we conducted the interviews with the representatives from these water associations.

These water associations represent members of more than one individual water utility and have a developed understanding of how to interact with the utilities. We wanted to know what information the water associations have identified as most helpful to the water utilities to narrow down our final recommendations from our initial ideas and to forge a bridge to the individual water utilities. To do so, we came up with a specific set of questions to be addressed:

- *What has been done by associations to support utilities, in general?*
- *What would be the best way to solicit input from personnel at the utilities?*
- *How can the associations and MassDEP work together to provide support to the water utilities?*
- *How do associations perceive the strengths and limitations of particular outreach and assistance strategies?*

We chose to contact the water associations because they serve in many cases as an overarching organization that deals directly with water utilities. An example would be that the New England Interstate Water Pollution Control Commission (NEIWPCC) works with the Board of Certification of Wastewater Treatment Plant Operators in training the wastewater operators for Massachusetts. Talking to associations was intended to help us further understand how associations and MassDEP can help water utilities as well as provide us with helpful tips on how we could best interact with the individual utilities.

We conducted interviews with seven experts from outside associations and agencies. The people we contacted were the directors and program managers of the Massachusetts Water Works Association (MWWA), the New England Water Works Association (NEWWA), NEIWPCC, Coastal Zone Management (CZM), the Massachusetts Water Pollution Control Association (MWPCA), the New England Water Environment Association (NEWEA) and the Environmental Protection Agency's (EPA) Region 1 office.

For setting up and conducting the interviews, we used the same general process as outlined in Objective 1. The questions we drafted specifically to ask people at associations are included in *Appendix C*. These questions were sometimes modified to fit the scope of a particular association. These questions can be found in *Appendix A*.

Objective 3: Gather Opinions on Assistance Needs from Water Utilities

Lastly, we interviewed planners and managers at utilities to understand their direct needs for planning to adapt to climate change. Both MassDEP personnel and association representatives recommended that we avoid references to "climate change" when speaking with utilities. We were recommended to contact utilities about "emergency planning" rather than climate change adaptation, because many people are still skeptics of climate change. With that in mind, we had very specific information we wanted to learn from them:

- *To what extent do utility operators feel prepared for emergency situations related to sea level rise, increasing temperatures, or an increasing storm intensity?*
- *How much more would operators prepare if they knew the number emergency situations is likely to increase in the future?*

- *How do utility operators think MassDEP could better prepare them for these future climate change risks?*
- *What type of support and recommendations would be the most helpful to better prepare utilities adapt to harsh climatic events?*

We chose to interview utility operators and planners at the grass roots level because they were the primary target audience and they best know their own needs. We wanted to speak with planners and operators from a diverse range of utilities. We used the following four criteria to select potential utilities to contact:

- **Location:** We wanted to select utilities with different locations relative to water such as coastal plants as well as inland, riverside plants. We did this because the location of the plant determines which climatic changes will affect it, and we wanted to ensure we captured utilities affected by the different types of climatic changes.
- **Size:** We wanted to choose a range of different sized utilities including a small one, a very large one, and some with a size somewhere in between the first two. Through interviews with associations we learned that small utilities would most likely need the most help with planning. We chose to select a very large utility because we felt it might be more receptive to our questions, or already in the planning process.
- **Degree of Plant Treatment:** We wanted to select wastewater treatment plants with a range of degrees of treatment. Some plants only treat water up to the secondary degree while others perform tertiary treatment. We wanted to select plants with different degrees of treatment because some plants with advanced treatment might be worried about certain effects that plants with secondary treatment would not consider.
- **Utility Operator Training Grade:** The grade of a wastewater plant determines how much training an operator is required to have before working at that plant. A higher grade means more training is required, with 7 being the highest, and 0 being the lowest. For public plants, the grade is typically between 5 and 7, and is typically 7. We wanted to cover a wide range of grades, but because most plants are grade 7, the majority of our selections ended up having a grade of 7.

After selecting the specific utilities to contact, we followed the same guided interview process as in Objective 1 and 2. A table of the wastewater treatment plants and drinking water plants with the criteria used to select each is located in *Appendix C*. We spoke with nine utility operators and planners at three wastewater plants and one drinking water plant. An image of the utilities we visited is shown in *Figure 14*. (Note the exact location of the Walter J. Sullivan Treatment Facility in Cambridge is not portrayed accurately due to security reasons). We created two sets of questions to encompass the different audiences. One set of questions was

asked to utility operators about emergency response preparedness (short-term planning) while the other set had a theme similar to the questions we asked associations (long-term planning). The lists of questions can be found in *Appendix A*.

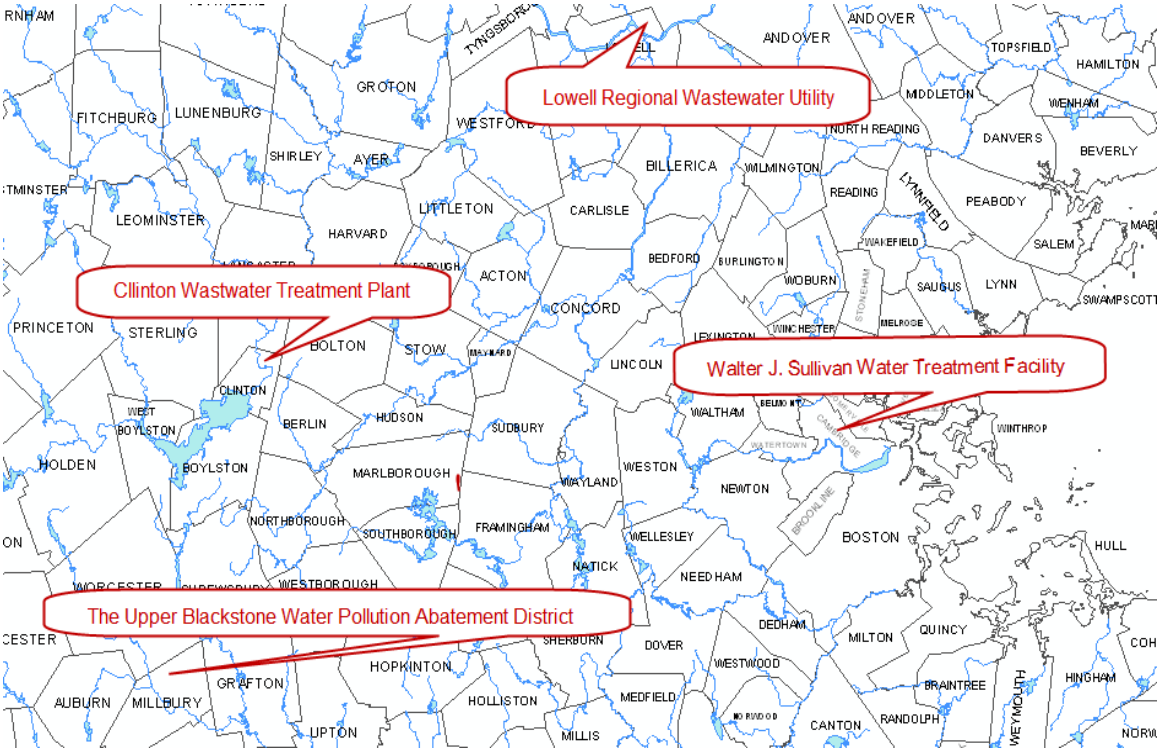

Figure 14: Map of Visited Drinking Water and Wastewater Treatment Plants

Objective 4: Create Recommendations to Provide to MassDEP

The final objective of our project was to create recommendations for MassDEP on how it can support Massachusetts water utilities. In this section we describe how we created our final list of suggested actions for the MassDEP to take.

Using the interview summaries and our background research, we created a list of initial recommendations. Once our interviews were complete, we narrowed down the initial suggested actions to our final recommended actions using three questions that our sponsor, the MassDEP, wanted answered:

- *How effective will this action be at helping the water utilities?*
- *How easy will this recommendation be for the MassDEP to implement?*
- *What will be the cost of implementation for both the MassDEP and for the water utilities?*

These three questions helped us determine the feasibility of each recommendation and also when each recommendation could be best implemented. By considering this we then divided our recommendations into short-term and long-term actions.

During our interviews we also identified the needs of the utilities in adapting to climate change and the constraints which utilities would face in the process. We created a list of four major needs and four major constraints which we additionally used judging our recommendations. The effectiveness of the recommendation was determined by how many needs the action meets as well as what constraints it worked within or around. The more needs a recommendation met, the more effective the action would be. However, if the recommendation went against a constraint, it was judged less effective than a recommendation that met the same needs and worked within or around that constraint. Using these needs and constraints as criteria, we organized our recommendations by how effective they would be over time, presenting short-term and long-term actions for MassDEP to consider.

The ease of implementation of a recommended action for the MassDEP was determined by only one constraint, the resources available to the MassDEP. This constraint was evaluated through communications with personnel at the MassDEP. If the action fell well within the MassDEP's resources, the action was determined to be easy to implement and we moved it forward to become an immediate action. If the resource requirements determined that the recommendation would be harder to implement, it was moved further back and became a long-term recommendation that the MassDEP could slowly work towards.

The cost of implementation for both the MassDEP and the water utilities was determined by the needs of the water utilities as well as the constraint on the resources available to utilities and the MassDEP. The cost to the MassDEP was placed in higher priority because of the greater availability of resources to the water utilities that was identified in our research. Higher costs to both organizations determined that suggested action become a long-term recommendation, while low cost actions were suggested to be implemented first.

4.0 – Findings

This chapter discusses in detail all of the relevant findings from our interviews. We have categorized our findings into two separate sections, the first of which identifies what needs the utilities and other stakeholders will have in adapting their systems to climate change. The second section discusses the constraints that stakeholders will face in making Massachusetts water utilities resilient to climate change. These interview findings were the basis for our recommendations to the Massachusetts Department of Environmental Protection.

The Needs for Climate Change Adaptation Planning

In this section we explain the needs of various stakeholders for climate change adaptation planning. Even though the utilities are the final audiences that need assistance for planning, the MassDEP and water associations also have needs associated with assisting the utilities. The data for these findings were provided by background research, personnel within MassDEP, directors and program managers at water associations, and also operators within the utilities themselves. The four major categories of needs we identified in planning for climate change include:

- **The need of funding for adaptation:** Utilities need funding for planning procedures, purchasing equipment and acquiring human resources before they can adapt.
- **The need of Information and education when planning:** Information available to stakeholders about climate related activity and climate change projections is sometimes not shared so there is a gap in education and information that is necessary to understand before any planning is done.
- **The need for political and public support when planning:** Water utilities need political and public support when planning because funding is shared within other town departments and therefore utilities must compete for town resources.
- **The need for increased planning capacity:** Many utilities are currently understaffed, especially small ones. Operators are worried about running the plant on a day to day basis while managers have other burdens to worry about on top of planning for what will occur in the future.

Funding-Related Needs Identified by Utilities

Utilities cannot successfully plan for the effects of climate change without sufficient funding from the community. The three major areas that require funding include planning, equipment and human resources.

The Need of Funding for Planning

Through many of our interviews we found funding to be considered the most important need when it comes to creating successful plans that prepare utilities for emergency situations related to extreme climatic events. A planner at the Massachusetts Water Resources Authority (MWRA) said that the need to plan for extreme weather conditions is important, and funding is likely to be the greatest need for water utilities in this planning. The EPA has taken the lead in the United States for climate change adaptation planning, so we interviewed one of their climate change experts. He also mentioned that funding for planning would be the main need.

Through interviews with utilities, we found that most were reliant upon funding from their community and their customers, while others received funding through MassDEP's State Revolving Fund (SRF) or other loan programs similar to the SRF. The SRF is a low-to-no-interest loan designed to help drinking water and wastewater-related infrastructure projects. This program provides 25% of its full budget to use for planning procedures.

The MassDEP Northeast Regional Director stated that only one of every ten utilities that applies for the SRF in Massachusetts actually receives funding. Rebecca Weidman, the director of water resource protection at the New England Interstate Water Pollution Control Commission (NEIWPCC) and Eric Worrall, the Wastewater Section Chief at MassDEP's Northeast Region Office, mentioned that utilities may not use the SRF because the process is somewhat complicated. These complications include the time the application takes to complete, the time it takes for a response back, and the way the council chooses their candidates considering there is limited funding.

The Need of Funding for Equipment for Emergency Situations

John Riccio, the superintendant of the Clinton Wastewater Treatment Plant, suggested that having spare equipment readily available would be helpful for utilities when dealing with emergency situations. During each of the two intense storms that occurred in mid-March, 2010, Clinton's plant was flooded by the Wachusett Reservoir Spillway release and they could have used such spare equipment. He suggested that backup generators, sand bags or temporary jersey barriers, pumps, and hoses would be the most beneficial types of equipment needed to minimize the effects of situations like one that occurred.

According to MassDEP experts at the Northeast Regional Office, backup generators are one of the types of equipment needed for some utilities in emergency situations. Through interviews with association directors we found that the MWRA is the only provider of mobile generators. However, these generators are from the WWII era and are not very reliable.

After touring the Lowell Wastewater Treatment Facility we found that water had been seeping through the building that houses their backup generators. As a result, tarps had to be placed above the generators to keep them functional, so they could be used in case of an emergency. Lowell's generators are outdated so replacement parts are not readily available to

purchase, which is why they are keeping protecting them as much as possible. Lowell identified the need for improved functional backup generators and also said having reliable ones readily available would be helpful in the future.

The Need of Funding for Human Resources

MassDEP directors for water programs in the Northeast have revealed that most utilities are staffed with just enough operators to manage the plant. This is one of the reasons for the lack of planning for emergency situations. Some water association directors we interviewed seemed concerned with utilities' lack of staff to handle daily tasks. They knew that losing an operator to sickness could cause difficulty in managing a plant, especially during emergency situations.

After visiting the Clinton Wastewater Treatment Plant and speaking with the superintendant, we were under the impression that the plant is currently understaffed. The operators only work at the plant for eight hours, whereas the plant is run autonomously for the other sixteen hours. An operator from the Lowell Wastewater Treatment Facility mentioned that the plant can be run fully autonomously. However, during emergency situations the plant is set to manual and is run by the operators. In this case, all personnel available need to react and help fend off any threats to the system.

Some utility managers claimed there is a definite need for emergency response planning. They said that if funding was available to hire more staff to help keep the plant up and running, especially during emergency situations, then they would hire more. Utilities could prioritize emergency planning into their schedules along with operating and maintenance.

Informational and Educational Needs of Planning

In nearly all of our interviews we were told that there is a lack of reliable information readily available to water utilities stakeholders regarding climate related activity, its effects on utilities, and how to overcome these obstacles. We found that information has been gathered by many groups, and if shared it could be of much use to all of these stakeholders in adapting to climate change. For example, the lead engineer at the Lowell Wastewater Treatment Facility provided us with historical data of rainfall totals for the City of Lowell for every month over the last 150 years. We analyzed this data and it showed that trends in the last 50 years pointed to an increase in rainfall total on a year to year basis. While this information might not be useful for the entire state, surrounding communities that would have received similar rainfall totals could make use of it.

A major obstacle utilities face when adapting to climate change is uncertainty in what to expect for a change in climate in the future. There are many different projections, most of which vary slightly depending on the historical data and the approach researchers use. Many reports we found dealing with climate change's effects refer to the NOAA or USGS as reliable

sources for making these predictions, which is why these were the main resources we chose to use for our background research. However, not even highly reputable sources like these can predict the future with accuracy.

Utilities would benefit from knowing the impact that a predicted change in climate poses to their system. There are several useful tools available that help display these adverse affects. However, many of these tools are not easily accessible to the average water utility. One tool that is helpful for visualizing climate changes affects is a Geographic Information System (GIS). This software has the capability of mapping different land features such as land elevation, flood zones, watersheds, rivers and lakes, all in the same image. For example, a GIS specialist has the ability to create a map using these features to account for a specific sea level rise or increased flood zone, and show the effects of a change in climate. While a map like this could be useful for a utility to visualize some effects, GIS software has some flaws such as its lack of accuracy in elevation mapping.

An efficient tool which uses Google imaging along with a technology known as Light Detection and Ranging (LiDAR) to accurately measure land elevation within six inches has recently been created by the Coastal Zone Management (CZM) organization. Similar to GIS, the tool can be used to visualize how climate change could affect a utility. CZM has released a beta copy of this tool, which depicts nine public buildings in the town of Hull, MA, with several hypothetical changes in climate, using both sea level rise and increased flood zones as their variables. This is a very powerful visualization tool to show real life scenarios of flooding; however, it is not currently accessible to all water utilities because of the lack of current data. Collecting LiDAR imaging data for the entire New England coastline was approved in April, 2010, and the data are expected to be available by May or June of 2010. This will potentially lead to an increase in the accuracy of climate change predictions for measured areas.

Many interviewees in MassDEP as well as from associations mentioned that plant operators and managers are generally unfamiliar with tools and projection methods to plan for climate change. They suggested that educating the operators and planners on the most accurate climate change projections, the tools with the highest visual impacts, and the most beneficial ways to protect their systems could prove to be an important process for adapting.

The increasing average age of plant managers is another concern for water utility stakeholders. Over the next five to ten years it is predicted that about half of Massachusetts water utility managers will retire. To address this concern a program known as “Operator Boot Camp” is being put together by both the New England Interstate Water Pollution Control Commission (NEIWPCC) and the Board of Certification of Wastewater Treatment Plant Operators. The program will educate current plant operators how to become managers of a plant. An operator we spoke with at the Lowell Wastewater Treatment Facility noted that even though he has a level 7 certification, which is the highest level available, he would find some level of difficulty in managing the plant during emergency situations without his manager

nearby. This suggests the importance of educating incoming water utility managers so they can be prepared for extreme climate events.

The Need for Political and Public Support When Planning

The need for political and public support to convey the urgency of the changing climate and its affect on water utilities was identified by most directors of water associations as an important topic. Public drinking and wastewater utilities are generally part of a town's Department of Public Works (DPW) which is funded by the local, state and federal governments. However, we learned through many of our interviews that water utilities believe they don't receive the consideration that they require, both in funding and in assistance with planning, from these governing bodies.

Within a town's DPW are several systems which are vital to a town's prosperity. Transportation infrastructure, parks, fields and other public facilities are all examples of other operations within the DPW that often must share a budget with water utilities. Fire stations, police stations and school systems are other examples of departments within a town with which a water utility may compete with for government funding. A town's budget is decided on by the town's local government, which is strongly influenced by the public opinion, both in elections and in town meetings. For a water utility to increase its funding, it becomes vital to have these groups of people behind them.

An operator at the Walter J. Sullivan Water Treatment Facility at Fresh Pond in Cambridge, MA mentioned that the plant's recent reconstruction was attributable to the town's support and budget. When touring their drinking water facility we noticed they were in an admirable position to take on a variety of problems. Even though the plant is ten years old, it was described by its chief operator as, "looking better than it did when it was built". The utility cost upwards of eighty million dollars to construct and this past year it was approved 1.75 million dollars for upgrades. Furthermore, it is also currently under budget.

It is also important for a drinking or wastewater utility to gain support and explore funding options from state and federal government. As previously discussed, the local government may be the key decider of how to divide up money within a town. However, the local government is not the wealthiest sector. There is far more money being distributed at the state and federal level.

The federal government and FEMA have created a grant that is intended to help homeowners flood-proof their homes. We learned from a contact at the Coastal Zone Management office that 150 communities in the commonwealth have already received money through this system. This shows the federal government's awareness towards the need to aid homeowners for an increasing flood risk. However, this support is not directed at water utilities. One MassDEP official noted that an increase in political support on the federal level would need to occur for a grant like this to be available to water utilities.

Through several interviews with MassDEP personnel and association directors, we found that awareness often comes only when a problem occurs. For example, the MassDEP was urging the Gloucester Drinking Water Treatment Plant to upgrade their infrastructure for many years. They had failed tests in the past, and were acknowledged as one of the utilities that required high maintenance by some MassDEP officials. Last summer, the Town of Gloucester had an 18 day boil order for their drinking water which was one of the longest on record. The state has now taken control in requiring a complete overhaul of the system, and is also running the project.

The Need for Increased Planning Capacity

Many of the government personnel and members of associations that we interviewed identified that most utilities are in need of better long term planning and had addressed this as a major concern. Long-term planning typically comes from town planning engineers and the DPW. Systems operators, on the other hand, are worried about keeping the system running on a day to day basis, and utility managers have other burdens to worry about on top of planning for what will happen to the utility in the future.

We gathered information from several interviewees from MassDEP and associations implying that the planning capacity of smaller systems is less developed than in larger ones. For example, a large system such as the MWRA, the source of drinking water and wastewater treatment for Boston and many of its surrounding communities, may already have a quality long term plan. We spoke to the MWRA's lead planner, Steve Estes-Smargiassi, who informed us that he and other planners had begun looking at climate change's affects within system upgrades. He mentioned that they would continue to address the issue through future plans. He also acknowledged that not all systems run as efficiently as the MWRA's.

As previously mentioned, many utilities are understaffed. Some small towns in Massachusetts don't have the personnel to create a long term adaptation plan, let alone the lack of resources. Through an interview with an executive director of an association, we discovered that many smaller utilities must hire private engineering consulting firms to plan and conduct upgrades to the town's systems. This proves to be less efficient and more costly for the smaller communities.

Smaller communities might be able to plan for emergency situations at their water utilities through Incident Command Systems (ICS) and Emergency Response Plans (ERP). An ICS is a set of people, policies, procedures, facilities and equipment that are integrated into a common organizational structure to improve emergency response operations (Auf der Hiede, 1989). An ICS is applicable to all emergency situations but in particular addresses intense storms such as those that might become more frequent with climate change. In the United States, all levels of government, from federal to local, are required to have an ICS and proper training as mandated by the Department of Homeland Security (DHS). Having an ICS is also a

requirement to receive any federal disaster aid money. However, when we spoke to Eric Worrall, the Deputy Regional Director of the Northeast Water Program in MassDEP, he mentioned that many of the towns' ICSs do not include their water utilities. The other way a community can help plan for emergencies is with ERPs. Emergency Response Plans are required for all water utilities by the MassDEP and are to be updated on a yearly basis. Known changes to the system must be recorded, such as new personnel, infrastructure and new equipment. However, after speaking with an operator at a drinking water plant, we found that ERPs are not reviewed by the MassDEP as thoroughly as some utilities may like.

These are examples of "no regrets" actions or strategies that a utility can take to protect their system from adverse impacts of climate change. We have found term "no regrets" throughout several MassDEP sources and use the term to help define suggestions later on in this report. "No regrets" actions or strategies can be defined as actions that will improve resources for future climate change events and improve other related resources without compromising other potential actions or causing other negative effects.

Constraints Associated With Creating an Adaptation Plan

When conducting our interviews, we often discussed the various challenges that have hampered the adaptation planning process. These obstacles were discussed with MassDEP water experts, water association directors and water utility planners. We have come up with a list of four major constraints that contribute to the challenges that hamper the planning process. Our recommendations to MassDEP, which are displayed later in the report, had to address all of these constraints:

- **Lack of communication between stakeholders**: Gaps of knowledge can hinder the adaptation planning process. Stakeholders possess tools and educational information that would be helpful for others to take advantage of, however, the communication between these stakeholders needs to be improved in order to make this information helpful.
- **Utilities' receptiveness to "climate change":** Climate change is a controversial topic worldwide. Climate change planners should recognize that some stakeholders are skeptical about the causes and effects of climate change. The topic of climate change should be presented cautiously in order for utilities to not be deterred from action due to their skepticism.
- **Limited capacity of utilities to take on new challenges:** Some utilities are burdened by the regulatory requirements that must be met on a day to day basis. Such utilities lack the capacity to complete additional projects beyond what is currently required.

- **Limited Resources of MassDEP:** Availability of MassDEP resources, both financial and human, will determine the feasibility of guiding the planning process. Our recommendations to MassDEP must recognize these limitations.

Lack of Communication Between Stakeholders

A distinct problem identified through interviews is the lack of communication between stakeholders and agencies across the commonwealth. There is information about climate change and actions available. However, the stakeholders possessing this information have not made it widely available to those who may find it the most useful. For example, a drinking water expert in EPA's Region 1 Office provided us with a list of current activities the EPA is pursuing related to climate change. One of these activities includes "Action Plans for Drinking Water Climate Change," a list of planned and ongoing action items to address climate change issues. She also informed us about the EPA's "Water Utility Climate Change Awareness and Risk Assessment Tool" (WUCCAT) which is scheduled for release in fall, 2010. This tool will be used to increase operators' awareness of the risks that climate change poses to a utility. She suggested that MassDEP's unawareness of the EPA's action plans and available tools is due to the lack of communication between the two agencies.

Another example of the lack of communication at the state regulatory level was revealed during an interview with an expert from MassDEP. He informed us of a Light Detection and Ranging (LiDAR) tool that measures ground elevations within 6 inches by sending a light detected ray from an airplane to the ground. The Massachusetts Water Resource Authority (MWRA) has used this tool to collect elevation data of the Boston area. However, some MassDEP experts were unaware that this data was collected, with some personnel even unaware of the ability to collect this type of elevation data. Some executive directors of associations indicated that this elevation collection method was new to them as well. This is more evidence of the lack of communication between stakeholders. Some associations and MassDEP experts suggest that improved communication between all parties would provide a better approach to update stakeholders of the ongoing work of different organizations.

Individuals' Receptiveness to "Climate Change"

Most of our interviewees had remarks about receptiveness to the topic of "climate change." We identified this receptiveness as a major constraint to be overcome when creating recommendations for adaptation. Most of the MassDEP personnel we interviewed believed that utility workers are likely to be climate change skeptics. In order to be cautious on the sensitive topic of climate change, MassDEP personnel and some association directors suggested that we speak to utility operators about "emergency preparedness" and "asset management." By adjusting the wording of our questions, we were able receive desirable information from operators about the topic without raising a potentially difficult subject. We were advised to

remember that operators are more focused on how to keep the plant running on a day to day basis than on long-term climate projections.

The lead planner at the MWRA suggested that utilities might be more receptive to past evidence of increasing storms and precipitation than to claims that the climate is changing. He agreed that focusing on emergency preparedness and asset management would be a good strategy when speaking with utility operators. Along with some other association directors, he said that directing focus towards utilities that believe in climate change might help persuade the disbelievers by demonstrating positive results from planning for adaptation.

Limited Capacity of Utilities to Take on New Challenges

Most MassDEP and water association officials noted that the priorities of utilities, such as the demand to fulfill regulatory requirements and their need to improve their aging infrastructures, will constrain our recommendations based on the fact that utilities may not be able to devote much of their time to adaptation planning.

The first constraint mentioned was the regulatory burden that the utilities are currently facing. Right now, MassDEP requires drinking water and wastewater utilities to comply with regulations for water quality to ensure the safety and health of the people, as well as the environment. The Director of the Drinking Water Program and the Director of the Clean Water Program at MassDEP both reported that the current water regulations that the utilities have to meet create a large burden for the operators and engineers. Ensuring that water is provided and discharged by the plant on a day-to-day basis also creates a large burden on the employees at the plant. When speaking with Eric Willett, the shift supervisor at the Lowell Regional Wastewater Utility, he commented that he has to constantly monitor the water quality by manually testing the water daily to ensure that there are not any water quality problems.

Willet also mentioned that he has to oversee many other operating and maintenance procedures carried out by the staff. Furthermore, the engineers at the Lowell plant are faced with several tasks such as upgrading the plant's facilities, ensuring water quality, separating the combined sewer systems in the city, and making changes to meet flood safety requirements. During our tour, he showed us the facility's Supervisory Control And Data Acquisition (SCADA) system. This computer program automates parts of the treatment process and allows the operator to monitor flows and operate the plant from an office or home computer. He said this is a very helpful program that helps removes some burden of needing extra personnel to manually operate parts of the plant.

Another constraint on the capacity of utilities is the age of some sections of the infrastructure. Some sections of pipe lines in many towns are well over 100 years old. With the age of the system increasing, many of the components can fail and cause major damage. The Director of the Drinking Water Program and the Director of the Clean Water Program at MassDEP explained that the Babson Water Treatment Plant in Gloucester, MA had originally

been built in the 1960's and had not received any major upgrades since its completion. As we previously explained, this plant had been encountering several issues, the main being a near record breaking boil-order for the city.

At the Lowell Regional Wastewater Utility, the lead engineer, Mike Stuart, told us that during dry weather one third of the water that the plant takes in is stormwater that filters through the ground and into cracks in the old pipes around the city. He said that some construction workers had recently been upgrading pipes, and that some sections of pipe they were replacing were actually made of wood. This shows how the city needs to upgrade its pipes in order to eliminate the excess flow of water through the plant. He told us that the plant treats an estimated 12 million gallons of stormwater per day that leak through cracks in the pipes.

The final constraint we identified for utilities is the variation in degrees of certification for operators across the commonwealth. Some interviewees observed that lesser qualified operators do not have the same level of experience that higher qualified operators possess. The inexperience at some utilities could lead to the inability of making proper decisions during emergency situations. In particular, Tom Bienkiewicz, the Director of the Board of Certification of Operators for Wastewater Plants, raised the issue that there are currently not enough new recruits for wastewater plant operators. As the current and last generations of operators begin to retire, there is an increasing concern for the Board and NEIWPCC that there will not be enough new operators to replace them. Bienkiewicz and some representatives from water utilities also expressed concerns with the training that new operators are receiving. Many officials told us that experience is a large factor when considering how operators make decisions during emergency situations. With up to half of experienced managers predicted to retire within the next decade, water utilities will face potential operational challenges.

Limited Resources of MassDEP

The final constraint we identified during our interview process was the amount of resources available to MassDEP to help utilities with climate change adaptation planning. This constraint will factor in greatly to the feasibility of our recommendations. Several MassDEP officials suggested that we take into consideration the cost of our recommendations, the time it would take to prepare them, and the availability of MassDEP human resources to take on the tasks.

In particular, the Assistant Commissioner of Planning at MassDEP, Douglas Fine, pointed out that the agency is currently underfunded and does not have the money to provide to utilities for planning to adapt to climate change. One suggestion an interviewee at MassDEP considered was to provide utilities with hands-on planning assistance. However, many officials expressed concern about which department would enact the procedure for the assistance. The MassDEP officials mentioned the agency does not currently have enough personnel available or funding to hire planners to provide assistance to the utilities.

The needs and constraints for creating an adaptation plan as described above emerged from our interviews and through our background research. These needs and constraints served as criteria for evaluating the recommendations suggested by our interviewees. From there we were able to create a list of final recommendations to present to MassDEP on how they can support Massachusetts drinking water and wastewater utilities for adapting to climate change. Those recommendations are presented next, in a form intended to serve as a stand-alone document for use by the MassDEP.

Climate Change Adaptation Assistance Models for Massachusetts Water Utilities

Recommendations to MassDEP

Adrian Catarius, John Flannagan, Saul Garcia and Matthew Weisman
Worcester Polytechnic Institute
May 4th, 2010

Short Term Recommendations

We recommend the MassDEP take the following actions in the near future to assist Massachusetts drinking water and wastewater utilities with adapting to climate change. These recommendations are listed in order of priority.

1. Develop Consistent, Effective Messaging with Other Stakeholders

- **Problem/Challenge:** The lack of communication and coordination between agencies and associations (including in-state, New England regional and national entities) that are conducting activities to help Massachusetts water utilities prepare for the effects of climate change is a barrier to progress. *Attachment A* contains a list of activities currently planned or underway, and in many cases the lead entity was un-aware of similar activities being conducted by the others.

- **Recommendations:** Create a network for sharing information between stakeholder groups on climate change adaption efforts for water utilities as well as any plans for assisting utilities. MassDEP, or perhaps an association of which MassDEP is a member, could assume a coordinating/convening role to support frequent communication with other agencies and outside organizations about their work on climate change adaptation for water utilities. Specific recommendations include using online publication resources as a means to share information, using other forms of electronic updates such as email newsletters, or having meetings about what work has been done. Additionally, we recommend MassDEP create a website to list publicly available resources, any meeting agendas and a key stakeholder contact list.

- **Pros:**
  - Meets needs by collaborating efforts to help utilities
  - Relatively easy to implement
  - Relatively low cost to the MassDEP
  - Implementation may develop communication beyond climate change adaptation for water utilities

- **Cons:**
  - There are some additional costs and required resources

2. Develop a Climate Change Readiness Module for Wastewater Operator "Boot Camp"

- **Problem/Challenge:** Approximately 50% of the managing staff in Massachusetts might be retiring in the near future. The New England Interstate Water Pollution Control Commission (NEIWPCC), MassDEP and the MA Board of Certification of Wastewater Treatment Plant Operators are working on a set of classes that current operators can take to prepare them to be plant managers. The first class is scheduled for the fall of 2010.

- **Recommendations:** Create or help create a module for the operator boot camp program that educates operators on how they can prepare themselves and their plants for intense storm events. Examples from the spring 2010 storm events are perfect to include this module. Covered material should include Massachusetts-specific historical data and real-world examples providing some tangible evidence that preparing for an increase in these extreme weather events should be a concern. See *Attachment B* for an example of such a historical data set, and *Attachment C* for an initial draft outline of the climate change adaptation segment/module for WWTO Boot Camp.

- **Pros:**
    - Directly helps operators and managers prepare for the future instead of telling them that they should plan
    - The Boot Camp training is being put together anyway; it should not be difficult to include this portion if the module can be put together ahead of time
    - Can focus on storm events rather than "climate change"
    - Helps train the people who will be constitute a majority of commonwealth operators in the future

- **Cons:**
    - Only speaks to wastewater operators
    - Does not speak to town planners or engineers who are charged with long-term wastewater treatment planning, major capital upgrades, etc.

3. Provide Models for Effects on a Community Drinking and Wastewater System Scale

- **Problem/Challenge:** Water utilities do not know how they might be affected by sea and river level rise. Many predicted effects vary widely making it difficult to choose which model to use for planning and designing.

- **Recommendations:** Gather a selection of relevant tools for sea and river level rise prediction that the utilities can use and provide them publicly, potentially on the MassDEP website. Gathering information and providing it to the utilities in a way they can understand and use is an extremely helpful action that MassDEP can take. We also recommend the MassDEP look into what sort of additional information or help the utilities would need to utilize the tools and provide that information or assistance in conjunction with the tools. A list of tools we have identified is located in *Attachment D*.

- **Pros:**
    - Provides specific information on how the utilities will be at risk
    - Many models available
    - Very convincing to utilities
    - Potentially very inexpensive
    - Some are easy to implement/use

- **Cons:**
    - Utilities might need training or assistance from MassDEP staff
    - Some models might require information that isn't available
    - Some models might not have the appropriate scale to use with utilities

4. Conduct a Statewide Assessment on Water Level Rise

- **Problem/Challenge:** Water utilities do not know how they will be affected sea and river level rise.

- **Recommendations:** Use latitude and longitude GIS location data on Massachusetts drinking water facilities and the new LiDAR data for the coast to perform a statewide analysis on the effects of sea & river level rise as predicted by the NOAA, Hayhoe, or IPCC. A further recommendation would be to conduct the assessment on different levels of water level rise, such as 1 foot, 3 ft, 6 ft and so on, similar to the assessment done by the CTDEP. With the new LiDAR data being provided, this analysis has become very feasible in the short term future. Additionally, if there are utilities determined to be at critical risk, such as being inundated by the 2050 projections, MassDEP could speak directly to the planners for that plant and see how MassDEP can best help the plant be prepared. However, LiDAR won't be available for the more inland areas of the state, MassDEP does not currently have complete location data for drinking water facilities, and the computers currently used for GIS mapping might not be able to handle the new LiDAR data.

- **Pros:**
    - Provides concise information to the MassDEP and the water utilities on who is at risk and how much they might be inundated by sea and river level rise
    - Could advance adoption of long-term planning frameworks and help garner political support
    - New LiDAR data will increase the accuracy of the projections
    - MassDEP already has some GIS elevation data, GIS locations of wastewater facilities and a GIS team for this assessment

- **Cons:**
    - There are no sea and river level rise projections specific to Massachusetts; analysis would have to use northeast regional projections which might be inaccurate at smaller scales.
    - Only analyzes risks of sea level rise to wastewater and possibly drinking water utilities; analysis does not take into account other effects climate change, such as storm flooding or temperature increases
    - New LiDAR data does not cover all of the state; might be needed to do accurate analysis on inland areas. Extra data gathering would be very expensive and time consuming
    - MassDEP needs latitude and longitude GIS location data for drinking water facilities and possibly new computers to do analysis
    - Does not focus on the operator audience

5. Hold/Sponsor Presentations on Climate Change

- **Problem/Challenge:** Providing key information on climate change to the water utilities and other affected audiences.

- **Recommendations:** Create or sponsor presentations, conferences, symposiums, forums, electronic publications and/or electronic communications on how climate change can affect water utilities, what actions can be taken and what resources are available. Presentations and conferences have a much stronger impact than just having written material available. *Most* of the information to make a presentation right now is readily available through USGS, NOAA and the IPCC. Also recommended is to have smaller, regional presentations for specific audiences such as plant operators, plant and municipal planners, plant and municipal engineers and water utility customers. These audiences are recommended to be split into drinking water and wastewater groups as well. See *Attachment E* for an outline of suggested material to cover in the presentations.

- **Pros:**
    - Informs audiences of the risks to water utilities and adaptation strategies that they might be unaware of
    - Depending on implementation, could advance adoption of long-term planning frameworks and help garner political support
    - Relatively easy for MassDEP to create and implement
    - Relatively low cost for MassDEP, other organizations might contribute to the funding
    - Materials used, such as slides and other presentations aids, can be made available publicly (e.g. via the MassDEP website and information distribution mechanisms) to have a wider reach
    - Effective way to motivate utilities to start acting
    - Presents directly to a broad range of audiences

- **Cons:**
    - Many people might not have the time to attend a conference or presentation event
    - Holding only one, broad-range conference likely will not effectively motivate all of these different target audiences; would need multiple sessions with a higher cost to the sponsor(s)
    - Some data might not be available to make the strongest case at this time.

6. Continue to Develop the Massachusetts Water/Wastewater Agency Response Network (WARN) System

- **Problem/Challenge:** Utilities must have access to the needed resources, such as equipment and staff, during emergency situations that might be more prevalent in the future because of climate change.

- **Recommendations:** Continue to promote the WARN system and its benefits to water utilities that are not currently participating. The Mass WARN system has already been implemented at some utilities during emergencies. However, not all utilities in the state are currently members of the system. Additional utilities will increase the effectiveness of the system. We also recommend research on what additional equipment would help utilities most in emergency situations, the cost of buying that equipment, the options for housing, maintaining transporting and setting up the equipment and funding options. Recommendations for additional equipment include backup generators, diesel pumps, ample length of hose for these pumps and temporary jersey-barrier type levees. Buying additional equipment would improve the overall effectiveness. Finally, we also recommend the MassDEP develop a database of drinking and wastewater utility operators in the state and make this list available explicitly to WARN members. This database would facilitate better staff sharing in times of need. The database should indicate operators' other useful licenses, such as a hydraulic license or a large vehicle driver's license.

- **Pros:**
    - WARN helps water utilities obtain FEMA emergency funding as well as supplying any equipment, staff or water that the utility may require in an emergency
    - WARN helps utilities prepare for future emergencies beyond climate change; "No Regrets"
    - Develops better communication throughout Mass water utilities
    - Shows utilities that MassDEP wants to help the utilities
    - Equipment can be potentially paid for by FEMA money or something similar
    - MWRA might be able to keep additional equipment housed and maintained
    - Already in place, little time and effort needed to make it better
    - Already received feedback saying system is very helpful for utilities

- **Cons:**
    - Potentially, MassDEP has to pay for the equipment and contracted staff
    - Potentially, MassDEP has to house and maintain the equipment

7. Evaluate and Ensure Emergency Wetlands Permits Allow Temporary Equipment Placement

- **Problem/Challenge:** Flood events threaten utilities. In some cases, the flooding can be avoided by setting up structures as temporary levees. However, to be effective, the levees might need to be placed within protected wetlands which the utility will need a permit to do.

- **Recommendations:** Evaluate the current MassDEP emergency wetlands permit process to ensure that it allows the placement of temporary equipment to protect water utilities. Temporary equipment includes temporary jersey-barrier type levees, generators, pumps and hoses. We also recommend the MassDEP investigate the speed of the process to ensure that it is short enough to be of use in an emergency situation. Finally, we recommend education on how to obtain an emergency permit in their outreach to treatment plant operators.

- **Pros:**
    - Helps water utilities prepare for emergency situations
    - Eases the regulatory burden that utilities face in emergencies
    - Can be applied to important infrastructure beyond water utilities
    - Relatively inexpensive and easy for the MassDEP to implement
    - Low cost to utilities
- **Cons:**
    - Puts wetlands at risk during emergencies
    - Process may not gain public approval
    - May require additional staff and resources for the Local Conservation Commission or the MassDEP to handle the permits

8. Suggest Incorporating Water Utilities into Their Community's Incident Command System (ICS)

- **Problem/Challenge:** Some water utilities in Massachusetts are not a part of their community's ICS. The ICS is already a very robust system for preparing a town and its resources for potential emergency situations. Incorporating water utilities into the system is a way to help them prepare for emergencies that might occur more frequently in the future because of climate change.

- **Recommendations:** Consider promoting water utilities' incorporation into ICS if such promotion is within MassDEP's jurisdiction. If not, recommend such action to the Department of Homeland Security.

- **Pros:**
    - Helps water utilities plan for future risks
    - Requirement for receiving disaster aid money
    - Beneficial beyond climate change adaptation efforts, "No Regrets"
    - Inexpensive for both MassDEP, the towns and utilities
    - Effective in identifying vulnerable areas and areas that need improvement
- **Cons:**
    - Possibly beyond MassDEP's jurisdiction to influence

9. Evaluate New Wastewater Plant Bypasses for New Construction

- **Problem/Challenge:** Wastewater utilities face challenges in handling additional flow to treatment plants during storm events. If there is too much flow and the plant does not have a way to handle it, the plant could face serious harm and potentially suffer damage or even be out of commission for a long period of time. A treatment bypass would allow the plant to handle higher flow rates with a decrease in the degree of treatment. Some plants do not have bypasses and the regulations of MassDEP require notification of bypasses to be able evaluate their use.

- **Recommendations:** Reevaluate current policy on the construction of wastewater plant bypasses and allow bypasses based on whether they would adequately protect the plant in times of high flows or not. The pollution caused by allowing bypasses during these emergency events is much less than harming the plant and putting it out of commission. Consider imposing some restrictions on what stage of treatment the bypass would be divert flow, the design amount of flow the bypass would allow and what sort of strict situation parameters would have to be met before the bypass is opened.

- **Pros:**
    - Helps water utilities prepare for emergency situations
    - Very low cost to the MassDEP
    - Very easy to implement
    - Will not conflict with regulations on Combined Sewer Overflows and Sanitary Sewer Overflows

- **Cons:**
    - Will be allowing untreated discharge
    - EPA might oppose construction plans and conflict with MassDEP's judgment
    - Does not help drinking water utilities

10. Suggest Incorporating Climate Change Resiliency into Current Design Manuals

- **Problem/Challenge:** Water utility planners, architects and engineers may need assistance in planning for the future.

- **Recommendations:** Determine what design manuals are being used by drinking water and wastewater utilities and whether they have already incorporated climate resiliency elements or plans into the manual. If not, make suggestions to the author organizations on how to incorporate planning and design for climate change into the manuals. A specific example would be to decide on the plant or upgrade operational lifetime, look at the projected amounts of climate change within that lifetime, and make revisions to the design to make it resilient with a margin of error.

- **Pros:**
    - Gives utility planners and engineers the information they need in a medium they are familiar with; very effective
    - Does not impose additional restrictions on water utilities
    - Has an influence beyond Massachusetts water utilities
    - Very low cost to the MassDEP
    - Very easy to implement
    - Relatively low additional costs to utilities that varies depending on design changes

- **Cons:**
    - Authors might refuse to revise their manual with climate change in mind
    - Planners and engineers are not required to use manuals

11. Promote Incorporating the Supervisory Control And Data Acquisition (SCADA) System and Training

- **Problem/Challenge:** Water utilities must monitor and operate their plants during both day-to-day operation and during emergency events.

- **Recommendations:** Promote incorporating the SCADA system into existing water treatment plants without it as well as new plants. We recommend promoting by adding it into the TR16 and any other design manuals that do not mention it, making it criteria for deciding SRF loan approval and putting it into the presentations and conferences. We also recommend training with the SCADA system for operators who are unfamiliar with it. Consider incorporating training into the Operator Boot Camp program.

- **Pros:**
    - Helps water utility operators better handle emergencies
    - Has a proven track record of greatly improving plant operation
    - Low cost to the MassDEP
    - Low cost to water utilities compared to other upgrades
    - Reputation is a very effective persuader
    - Helps utilities with more than just climate change and emergencies; "No Regrets"
    - Helps utilities with their regulatory burden
    - Promotion can be incorporated into revisions of the design manuals
    - Training can be incorporated into Operator Boot Camp

- **Cons:**
    - There are some costs to the MassDEP and the water utilities

Long Term Recommendations

We recommend the MassDEP consider and work towards the following actions in the long-term. Our analysis suggests that the timing and resources available do not make these recommendations effective or feasible in the short-term.

1. Expand Water Utilities' Requirement for Emergency Response Plans (ERP)

- **Problem/Challenge**: Massachusetts water utilities might not all have a plan for emergency situations. Those that do have plans might not be prepared for the emergencies that arise from climate change

- **Recommendation**: Expand the requirement to have an ERP to wastewater utilities. Also, we recommend MassDEP consider ensuring that the plans created by the utilities are thorough by providing feedback to utilities instead of asking the utilities to self-certify ERPs as has been done in the past. Finally, MassDEP can look into options on how they might help utilities practice their ERP such as doing a tabletop exercise or scenario.

- **Pros**:
    - Helps utilities prepare for the long-term future
    - Can meet education need by having the MassDEP help utilities draft their ERPs
    - Could work in conjunction with SRF incentives as a criteria for getting a SRF loan
    - Would cost relatively little for both the MassDEP to regulate and for the utilities to come up with a plan
    - Would help utilities prepare for more than just climate change effects
    - Can link water utility ERP to larger municipal response plans

- **Cons**:
    - Exemplifies need for climate change information for specific projections and how to adapt.
    - Might not be effective if operators and planners do not put the effort in
    - Regulation on the drinking water side has been met with unsatisfactory comments on how the MassDEP does not have the resources to make sure all utilities have a current and effective plan
    - ERP will be less effective without practice

2. Incentivize Climate Change Adaptation within the State Revolving Fund (SRF) Loan Program

- **Problem/Challenge**: The cost to water utilities of planning and implementing upgrades to their systems.

- **Recommendation**: Look into options for incentivizing climate change adaptation within the SRF loan program in Massachusetts, and monitor current incentive practices in other areas for effectiveness. Monitoring current incentive practices in other areas can help identify effective procedures. Options include offering additional SRF points for addressing potential climate change impacts into planning and upgrades; additional points for adaptation measures during typical upgrades and construction; funding specifically for long-term adaptation plans; requiring a climate action plan for applying to the SRF program; or requiring a recently updated/reviewed ERP that addresses sea level, storm and temperature risks. Some drawbacks include that many utilities need the SRF funding simply to meet current regulations and maintain plant operation. Prioritizing plants that have climate adaptation plans above those trying to meet basic regulations is not desirable. Furthermore, the topic of climate change is not widely agreed on and requiring plans to receive funding may prompt some utilities to stop using the SRF program, reducing its influence.

- **Pros**:
    - Directly helps utilities by providing them funding for adaptation measures
    - Getting additional funding decreases the burden on towns being served which helps garner political support
    - Provides climate change information if assistance is provided for doing vulnerability assessments or planning
    - Has been implemented before concerning mitigation techniques in Maine
    - Inexpensive and easy for the MassDEP to implement

- **Cons**:
    - Not all utilities use the SRF program; incentives will not reach those utilities
    - Might deter some utilities away that use it now because of additional complexity
    - Might deter climate change skeptics from using the program
    - Exact implementation option will determine effectiveness
    - Some required elements within the SRF cannot be changed

3. Require Climate Change Adaptation Plans

- **Problem/Challenge:** There is currently no way to guarantee that every water utility in Massachusetts will plan for climate change.

- **Recommendation**: Require climate change adaptation plans once other measures are in place to provide sufficient support and resources to water utilities. Because climate change is still a subject that is not widely agreed on now, we do not recommend passing a regulation for all utilities to have a climate change plan presently. In the future, as climate change becomes a more widely agreed upon problem, a regulation would be very effective.

- **Pros**:
    - Forces all utilities to start planning for climate change
    - Can help garner political support if utilities express to their service area that they have to spend money to maintain their permit
    - Enforcement of regulations is sometimes the only way to get utilities to listen
    - Low cost of implementation for the MassDEP
    - Easy to implement

- **Cons**:
    - May require specific climate projections for specific technical regulations
    - Regulates something that is not currently agreed on by all members of the water utilities
    - Utilities may have a hard time meeting the code on top of other responsibilities
    - Potentially very expensive for utilities
    - Additional regulations for utilities might create unfavorable opinions about the MassDEP

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Appendix A – Interview Questions

This appendix lists the specific questions we asked to each of our interviewees, which include MassDEP personnel, water associations, and water utilities.

Questions for MassDEP Personnel

- Could you please give us a brief introduction of yourself including what you do here and your area of expertise?
- From your perspective, what risks to drinking water and waste water infrastructure do you associate with a changing climate?
- Do you see a need for water utilities to plan to adapt for these forthcoming risks either now or in the near future?
- Do you think the utilities themselves are worried about the impacts of sea level rise to Massachusetts drinking water and wastewater utilities? How about an overall increase in the temperature? What about a decrease in precipitation frequency but an increase in intensity?
    - If yes to any of the above, does MassDEP, or any association or organization you know of, have any plans to help utilities adapt to these changes?
    - If so, do you have any material that you can share with us?
    - Do you know of any specific utilities who have developed or are developing plans specifically to adapt to these changes?
- What influence does DEP, as a state regulatory agency, have over individual water utilities to implement planning procedures?
- What do you see as a difficulty for Mass. water and wastewater utilities to create and implement an adaptation plan?
    - Costs? Do you associate a higher cost to adding climate change adaptation planning to the association's agenda (or individual utilities)? Would it require extra resources to start or would it be another task for the current planning team?
    - Lack of political will and/or institutional structure to plan for changes? Who would / should take the lead for utility planning?
    - Lack of education on topic? Uncertainty about specific effects in Massachusetts over time? Lack of materials or information geared to appropriate scale of utility system?
    - Lack of longer term planning framework to advance planning efforts?
    - Any other obstacles or challenges?
- What can MassDEP do to facilitate the planning process?
    - Would you prefer to see guidance material or receive hands-on assistance from experienced planners?
    - Should some planning / preparation be required of utilities in Mass?

- Do you think the utilities (DW and WW) will find materials aimed at informing them of the risks climate change imposes on their infrastructure useful?
    - What information would be most helpful in explaining the risks to these utilities? Should we give specific examples of how the climate is expected to affect their system, how the climate is going to change in Massachusetts/New England area, and/or specific other communities that have already started planning and implementing a climate adaptation plan with examples of actions taken?
    - What medium (print, workshops, site visits, on-line resources, etc.) would be most accessible to the entirety of your association?
- We would like to contact applicable organizations/associations (EPA Region I, NEWIPCC, NEWWA, MWWA, etc.) and individual drinking and wastewater utilities, both public and private, to continue gathering information. Do you have any recommendations on who we might contact that would represent a broad range of different utilities?
    - Small, large, coastal, inland, wealthy, poor, complex, simple, high and low elevations, county wide, single town, etc.
- Do you mind if we contact you in the future for feedback concerning any material or information that we may come up with in the future?

Questions for MassDEP GIS Program Director

- Could you please give us a brief introduction of yourself including what you do here and your area of expertise?
- Do you have GIS data mapping any of the following records relevant to drinking and wastewater utilities?
    - Elevation
    - Major and Minor surface water plants
    - Ground water discharges
    - Pumping stations
    - Flood plain data
- Are there any discrepancies or grey areas associated with using GIS data in this sort of study?
    - Is there any information you wish to visualize but data is not provided for?
- Another person we talked to had suggested that MassDEP should do a widespread study on the effects of various amounts of sea level rise to water utilities in Massachusetts using GIS data. Using these projections, the DEP can then inform the regional areas of the risks that they face and prioritize helping the critically affected utilities. Do you think that this sort of study is feasible?
- Are you aware of any other techniques for predicting this sort of scenario that might provide better results or be easier to use?

- Is there anything on the smaller scale that might be available to individual utilities with little to no technical knowledge?
- If available, would it be possible for us to look at this data?
- We sent you our summary of the StormSmart resources, do you think this sort of information would be helpful to key stakeholders in MA?
- Do you think this data would be helpful for any type of documenting other than for stakeholders? How?

Questions for Water Associations

- Does your association have any concerns about the impacts of sea level rise to Massachusetts drinking water or wastewater utilities? (dependant on which association we are talking to)
    - If so, what are they?
- Does your association have any concerns about an overall increase in the temperature affecting the performance of Massachusetts drinking water or wastewater utilities? (dependant on which association we are talking to)
    - If so, what are they?
- Does your association have any concerns about an increase in storm intensity but a decrease in precipitation frequency impacting Massachusetts drinking water and wastewater utilities?
    - If so, what are they?
- If your association has any concerns, do you have any plans or know of any utilities with plans to adapt to these effects?
    - If so, do you have any material that you would be willing to share with us?
- Do you, as a water association, see a need to plan to adapt for these forthcoming risks either now or in the near future?
- What influence do you, as a water association, have over individual water utilities to implement planning procedures?
- What do you see as a difficulty for creating and implementing a climate change adaptation plan?
    - Do you associate a higher cost to adding climate change adaptation planning to the agenda? Would it require extra resources to start or would it be another task for the current planning team?
- What can MassDEP do to facilitate the planning process for utilities?
    - Would you prefer to see written guidance material, conferences and forums on the risks of climate change to water utilities, hands-on assistance from experienced personnel or a mixture of both?

- (If they do not view the risks of climate change as important items) Would you, as water association, use material aimed at informing water associations and utilities of the risks climate change imposes on their infrastructure?
    - What information would be most helpful in explaining the risks to your association? Should we give specific examples of how the climate will affect their system, how the climate is going to change in Massachusetts/New England area and/or specific other communities that have already started planning and implementing a climate adaptation plan?
    - What medium (print, workshops, site visits, on-line resources, etc.) would be most accessible to your association's workforce?
- We would like to contact individual drinking and wastewater utilities, both public and private, to continue gathering information. Do you have any recommendations on who we might contact that would represent a broad range of different utilities?
    - Coastal, inland, wealthy, poor, complex, simple, high and low elevations, county-wide, single town, etc.
- Do you mind if we contact you in the future for feedback concerning any material or information that we may come up with in the future?

Questions for Coastal Zone Management (Association)

- Could you please give us a brief introduction of yourself including what you do here and your area of expertise?
- Could you give us an overview of the assistance that CZM and the StormSmart program are giving to coastal communities in Mass. to help them be better prepared for storms and predicted coastal impacts associated with global climate change?
    - In particular, can you highlight any efforts that would be particularly useful for helping a community prepare for impacts to their key infrastructure such as water and power utilities, public buildings, roads, etc.
- Can you tell us more about the pilot program in Hull, MA?
    - We have heard about the tool used to visualize the effects of specific flood heights in 3D, are there any other tools or methods being piloted in Hull?
    - What need was the 3D simulation used to fill in Hull?
    - For the 3D visualization, did the data needed already exist or was new data required before the simulation could be run?
- Do you think there are any drawbacks to the approach SS/CZM used?
- What sorts of changes have been made in communities because of the StormSmart program?
    - Were/are there any changes planned for public infrastructures such as the school, post office, wastewater treatment plant?

- Do you think the tools and methods used in Hull would be useful to other coastal communities?
    - If yes, how soon?
- Do you think the tools and methods used in Hull would translate well to riverside communities as well?
    - If yes, how soon?
- Are there are other communities that are putting a significant effort towards adapting for storms like Hull?
- Do you think that results of predicting the changes in sea level rise and flood levels for communities would be useful to water utilities with facilities in the area?
- Are these tools and methods something that MassDEP could use to help water utilities adapt to climate changes like sea level rise and more intense storms/flooding?
- Does StormSmart/CZM work directly with towns or is the guidance primarily written material?

Questions for Water Utility Operators

- Could you please give us a brief introduction of yourself including what you do here and your area of expertise?
    - Are you part of a water association such as MWWA, NEIWPCC, etc?
- Does your facility have an emergency plan in place for flooding, an inflow of too much water to the reservoir, collection, system failure, bacterial contamination, biological filtering washout, erosion (on the coast)?
    - Does the plan cover other components in the system such as pumping stations, access points, etc?
    - When was this plan put together?
    - Are all the members of this plant aware of the plan and familiar with its steps?
- Have you experienced any of the above emergencies or any other ones during your career here?
    - Did experience from previous emergency situations help you with decision making during these events?
    - Are you worried about the lack of experience in new operators contributing to the severity of an emergency?
    - Do you think that if the trend is to see an increasing frequency in these sorts of emergency events, that a larger emphasis needs to be put on emergency training in new operators now?
- If we told you that intense storms, flooding erosion and bacterial contamination events would be increasing in the near future, would you want to have a revised plan in place to cover these events better?

    - Do you think that with an increase in these emergency events, more emphasis needs to be put on emergency planning efforts in water utilities?
    - Would you like to see your plant change to adapt to better handle these events?
- Do you think it would be beneficial to have your plan reviewed on a regular basis by your staff to assess effectiveness as well as boost preparation?
    - How would you feel if this became a state-wide requirement to have recurring reviews of your emergency plans?
- Have you conducted a vulnerability analysis on your facility?
    - When was this analysis done?
    - Does it cover any vulnerability associated with water level rise, storm events and temperature such as inundation, overloading, boil alerts, etc.?
    - Do any of these vulnerabilities strike you as a priority for your utility to address now or in the near future?
    - If you could lessen the effects of these vulnerabilities during routine O&M or upgrades, would you?
    - Do you determine when a specific component is no longer operating correctly and requires replacement/upgrading?
    - What are your general criteria for deciding when that component requires replacement/upgrading?
- Is your emergency plan part of a larger town/city emergency planning effort?
    - If not, do you think it should be?
- Are you a member or participant in the Water/Wastewater Agency Response Network (WARN)?
- MassDEP wants to help water utilities prepare and adapt for the future risks of water level rise and increasing storm intensity, do you have any suggestions on what sort of information or guidance that can be provided to help water utility operators with preparations?
- As both MassDEP and the water associations continue to develop methods to increase emergency preparedness, would you be interested in giving some feedback on their ideas?

Questions for Water Utility Planners

- Could you please give us a brief introduction of yourself including what you do here and your area of expertise?
- How many households in general does your water system serve?
- How high above sea level is your main treatment facility?
    - How high above sea level are your other critical system components such as pumping stations?
- Are your system components currently within the predicted 100-year flood plain?

- How old is the oldest, still functioning section to your infrastructure?
    - What is your timeframe for upgrading your aging or defunct sections?
- Do you have any current issues in your infrastructure that require your attention (yes or no)?
    - Do you determine when a specific component is no longer operating correctly and requires replacement/upgrading?
    - What are your general criteria for deciding when that component requires replacement/upgrading?
- Have you experienced an emergency related to intense storms, high temperatures or sea level during your career here?
- During the planning for your next repair or upgrade, would you consider reviewing the risks of a rising sea level, increasing storm intensity and/or a rise in temperature in design or specs?
- Historical data concerning sea level, average temperature and storm intensity shows that all 3 have increased within the past 50 years and there is a high probability that they will continue to increase. Do you have any concerns about the impacts of sea level rise to your drinking and wastewater utilities?
    - If so, what are they?
- Do you have any concerns about the impacts of an overall annual temperature increase to your drinking and wastewater utilities?
    - If so, what are they?
- Do you have any concerns about the impacts of increasing storm intensity flooding to your drinking and wastewater utilities?
    - If so, what are they?
- If you have any concerns, do you have any plans to make changes within the utility to withstand these effects?
- Do you, as a utility, see a need to plan to adapt for these forthcoming risks either now or in the near future?
- What do you, as a utility, see as a major road block for creating and implementing an adaptation plan?
- What can the DEP do to facilitate the planning process?
    - Would you prefer to see some form of written guidance material or receive hands-on assistance from experienced planner?
- Do you belong to a water association that is comprised of other, separate water utilities?
    - If the representatives of the water association came to you encouraging or requiring you to plan to adapt the utility for storms, sea level rise and temperature increase, how would that affect your decision making concerning planning? Would it expedite the process or would it not affect it?

- Would you use material aimed at informing water utility planners of the risks these changes impose on their infrastructure?
    - What information would be most helpful in explaining the risks? Should we give specific examples of how the changes will affect the system, how much sea level rise, storm intensity and temperature will change in Massachusetts/New England area and/or specific other communities that have already started planning and implementing an adaptation plan?
    - What medium would be most accessible to the entirety of your workforce? Would you be more apt to use a short pamphlet or some form of online resources?
- Do you mind if we contact you in the future for feedback concerning any material or information that we may come up with in the future?

Appendix B – Form Letters to Associations and Utilities

This appendix displays email forms that we used when contacting associations and utilities. Also included is the revised abstract that was sent out to utilities.

Email Form Letter to Associations

Dear ____,

We are a group of students from Worcester Polytechnic Institute working full time from 3/15 - 5/7/10 on a joint project with the Massachusetts Department of Environmental Protection. The goal of our project is to support Massachusetts drinking water and wastewater utilities by creating guidance and/or providing assistance for climate change adaptation planning. We have questions regarding specific planning for water utilities that we would like to ask you either in person or over the phone. We expect the interview will last no longer than one hour.

After we complete the information gathering phase of this effort, we will be presenting MassDEP with recommendations about assistance they could provide to drinking water and wastewater utilities regarding adaptation planning. We will offer to share these recommendations with all interviewees in early May 2010.

Attached, please find a list of our questions as well as a summary of what our project hopes to accomplish. Our institution requires either verbal or written consent and we can provide confidentiality regarding your response if requested. It would be helpful for us if you would allow a recording of our conversation to be made. We would like to meet with you during the week of 3/22-3/26 if possible. Please get back to us via email (madep2010@wpi.edu) or by calling at (617)-292-5860 to suggest a few possible dates/times. We look forward to hearing back from you!

Thank you for your consideration,
Adrian Catarius
John Flannagan
Saul Garcia
Matt Weisman

Email Form Letter to Water Utilities

Dear _____,

We are a group of Worcester Polytechnic Institute students conducting a project on how drinking and wastewater utilities in Massachusetts are going to be affected by climate changes such as increasingly intense storms, a higher sea level and a higher average temperature. We are currently working full time at the Massachusetts Department of Environmental Protection in Boston. Our project's goal is to provide MassDEP with recommendations on how they can best assist and provide guidance to water utilities in need of protecting themselves against these potentially destructive weather related issues.

So far in our project we have talked to MassDEP and EPA experts, as well as multiple water associations such as NEWWA, NEIWPCC and Coastal Zone Management. Our next step however, is to meet with managers, planners and operators of specific drinking and wastewater systems.

We are selecting a variety of types and sizes of systems and we have identified (UTILITY NAME HERE) as a utility we would like to evaluate and get your input and views on these issues. (EXPLAIN WHY THEY WERE CHOSEN). We wish to schedule these interviews sometime over the next two weeks. Our preference would be to visit your facility first hand, however because of transportation issues we may need to conduct the interview over the phone. The interview should last no longer than an hour and we have attached the list of questions which we will be asking.

Thank you for your consideration,
Adrian Catarius
John Flannagan
Saul Garcia
Matt Weisman

Revised Abstract Sent to Water Utilities

This project focuses on how climate changes such as intense storms, a rise in sea level and higher temperatures can affect water infrastructure. Our goal is to provide the Massachusetts Department of Environmental Protection with recommendations on how they can support drinking water and wastewater utilities with adapting their infrastructure to protect against potentially harmful weather related events. Through our initial research we learned about projections of what type of weather issues we can expect, the way our water infrastructure works, ways in which the infrastructure can be affected by these issues and what plans others already have in place for protection. Next we contacted major water associations and other professionals with a background in drinking and wastewater treatment in order to get a deeper understanding of our project and decide on the best method to complete our task. We are currently in the process of contacting and interviewing people at specific water utilities in Massachusetts. We hope to work with them to create recommendations for adaptation planning by tailoring their needs with techniques previously proposed by similar utilities. Our final deliverable will be a report with recommendations on how the Massachusetts Department of Environmental Protection can best provide assistance and guidance to utilities in need of protecting themselves against potential weather related concerns.

Appendix C – Criteria for Selecting Specific Water Utilities

Table 3: Criteria for Selecting Wastewater Treatment Utilities

Utility	Coastal (Y/N)	Elevation Above Sea Level	Riverside (Y/N)	In flood Plain (Y/N)	Serves Single/Multiple Towns	Size (MGD)	Grade of Facility	Degree of Treatment
Barnstable	X	?		?	Single	4.2	7	Advanced
Brockton				?	Single	19	7	Advanced
Chatham	X	?		?	Single	0.2	4	Secondary
Clinton			X	?	Multiple	3	7	Advanced
Cohasset	X	?		?	Single	0.4	3	Secondary
Edgartown	X	?		?	Single	0.75	7	Advanced
Fall River	X	?		?	Multiple	30.6	7	Secondary
Gloucester	X	?		?	Single	7.24	5	Primary
Haverhill			X	?	Single	18.1	7	Secondary
Holyoke		~15-21 meters	X	500 yr	Single	17.5	7	Secondary
Hull	X	~0-3 meters		100 yr	Single	3.07	5	Secondary
Kingston	X	~24-33 meters		partcially in 500 yr	Single	0.375	0	Advanced
Lowell		~15-21 meters	X	part 100 yr	Multiple	32	7	Secondary
MWRA - Deer Island	X	~0-5 meters		100 yr	Multiple	1270	7	Secondary
Newburyport	X	?	X	?	Single	3.4	6	Secondary
Plymouth	X	?		?	Single	3	6	Secondary
Springfield			X	?	Multiple	67	7	Secondary
Planned Contact								

Table 4: Criteria for Selecting Drinking Water Treatment Plants

Utility	Coastal (Y/N)	Elevation Above Sea Level	Pondside/Reservoir (Y/N)	Riverside (Y/N)	In flood Plain (Y/N)	Serves Single/Multiple Towns	Size (MGD)
Ashland			X		?	Single	6
Cambridge		~0-3 meters	X		500 yr	Single	24
Falmouth	X	~3-6 meters	X		no	Single	1.5
Gloucester	X	?			?	Single	Uknown
MWRA - Plant in Marlborough		~87-90 meters			no	Multiple	405
New Bedford	X	?			?	Single	45
Springfield - Plant in Westfield				X	?	Multiple	60
Swansea	X	?		X	?	Single	2
Worcester - Plant in Holden		200 + meters	X		part 100/500 yr	Single	50
Planned Contact							

Appendix D – Deliverables to MassDEP

This appendix displays our final deliverable documents that we provided to MassDEP along with the main deliverable located within the report.

Current List of Activities

This is the list of activities that various associations and stakeholders are currently performing, or planning to implement shortly.

Table 5: List of Current or Planned Activities by Associations and Stakeholders

Part 1

Title	Main Affiliate(s)	Region
Massachusetts Water Agency Response Network (MAWARN)	MassDEP	MA
Operator "Boot Camp"	NEIWPCC/Board of Certification	MA/New England
StormSmart Coasts Program	StormSmart Coasts/CZM	MA Coast
Climate Ready Estuaries Program	EPA	US
Climate Ready Water Utilities Working Group	NDWAC	US
Drinking Water Climate Change Roles for EPA New England	EPA Region 1	New England
Advanced Hydrologic Prediction Service	NOAA	US
Incident Command System (ICS)	DHS/FEMA	US
Massachusetts Drinking Water Regulations; 310 CMR 22.04 (13)	MassDEP	MA
TR-16 guide for design of wastewater facilities	NEIWPCC	New England
Green Project Reserve	NJDEP	NJ
Cape Cod Commissions (CCC)	CCC	Cape Cod
Massachusetts Emergency Management Agency (MEMA)	EOPSS	MA
Climate Change Adaptation Advisory Committee (CCAAC)	EOEEA	MA

Part 2

Title	Description/Purpose	Timeframe
MAWARN	Create a network of utilities to share resources in times of need	Ongoing
Operator "Boot Camp"	Train wastewater plant operators on how to assume a management role in the future	First class in Fall 2010
StormSmart Coasts	Help coastal communities address challenges from climate change among related issues	Ongoing, 5 Pilot communities being worked on: Boston, Hull, Duxbury/Kingston/Plymouth, Falmouth and Oak Bluffs
CRE Program	Help estuary communities adapt to climate change	Ongoing, provided assistance to 6 communities in 2008 and 8 in 2009
CRWUWG	Provide recommendations to NDWAC on how to help water utilities adapt to climate change	Final Meeting May 5-6, 2010
Drinking Water Climate Change Roles for EPA New England	Draft action plans for helping drinking water utilities adapt to climate change	Some actions ongoing, some within a year, others without a timeframe
Advanced Hydrologic Prediction Service	Online prediction tool for both sea and river water levels	Ongoing
ICS	Framework for action during emergencies	Ongoing, required by DHS for all levels of government
310 CMR 22.04 (13)	Requires all drinking water utilities to have an Emergency Response Plan	Ongoing
TR-16	Guidebook on the design of wastewater treatment works	Available, revised infrequently
Green Project Reserve	Proposal to provide a certain amount of the SRF loans to green projects	Was Available for public comment until March 29, 2010, actions after that not announced
CCC	Land-use planning and regulatory agency, beginning to worry about climate change and coastal resources	Ongoing
MEMA	Responsible for coordinating federal, state, local, voluntary and private resources during emergencies	Ongoing
CCAAC	Advise the EOEEA to study and make recommendations on strategies for adapting to climate change	Final Recommendations delivered Spring 2010

Climate Change Historical Data

Sea Level Rise in Boston, MA Since 1920

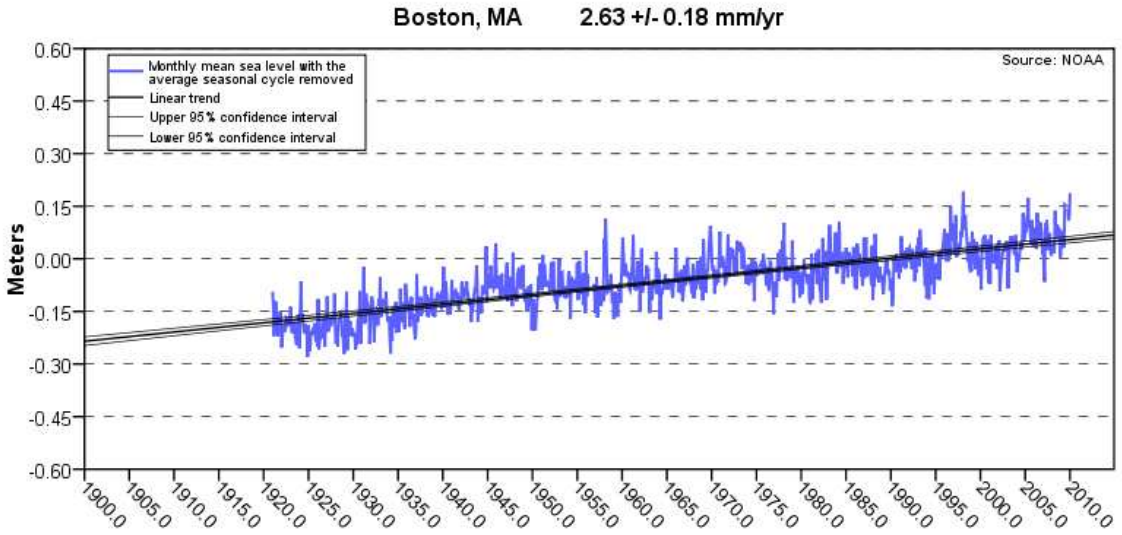


Image Courtesy of U.S. National Oceanic and Atmospheric Administration (NOAA)

Boston's mean sea level growth is 2.63 millimeters per year. That accumulates to approximately 11 inches for the last century. Massachusetts has lost an average of 65 acres of land a year due to the rising sea levels. This occurs mainly in Cape Cod and the South facing shores of Massachusetts near Rhode Island. This information does not take into account erosion which may occur over the passing years. The trend is not linear because as temperature increases sea level is expected to rise almost 22 inches in the 21st century (NOAA, 2009).

Massachusetts Mean Annual Temperature

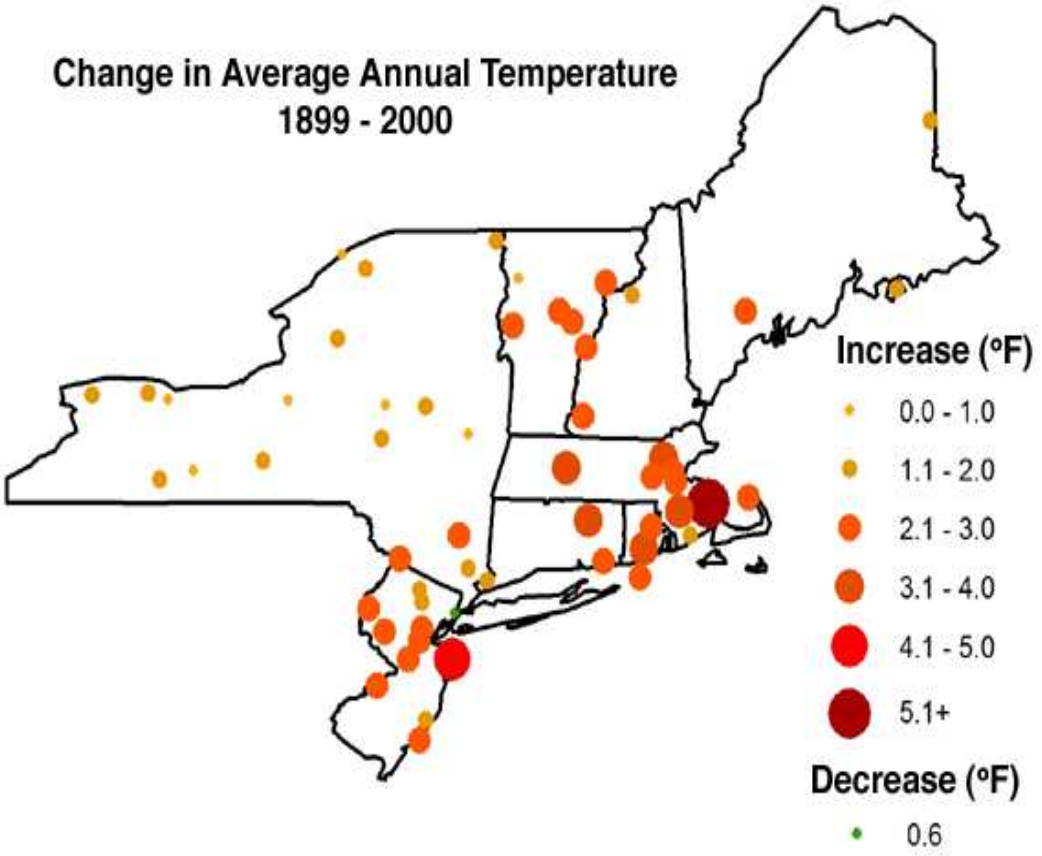


Image Courtesy of U.S. National Oceanic and Atmospheric Administration (NOAA)

Annual Temperatures have increased approximately five degrees in some parts of Massachusetts from 1899-2000. Warmer temperatures particularly occur near the sea. Massachusetts as a whole has seen varying yearly average temperatures, but the trend shows that there has been a two degree increase from 1960 to 2010.

Massachusetts Mean Annual Precipitation

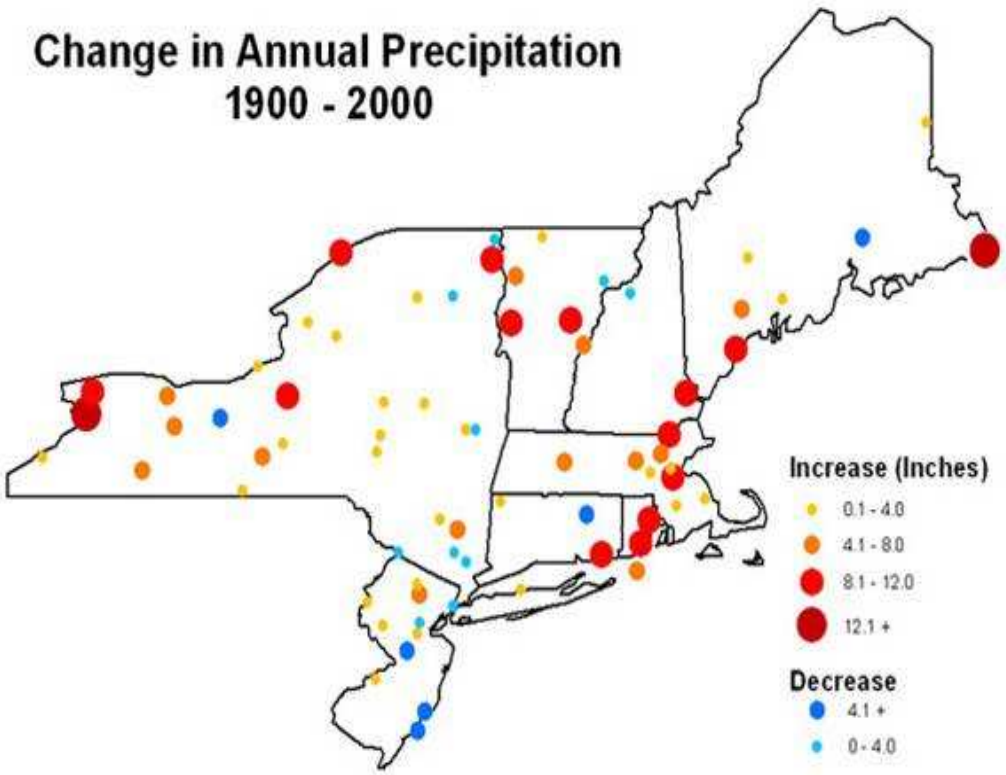
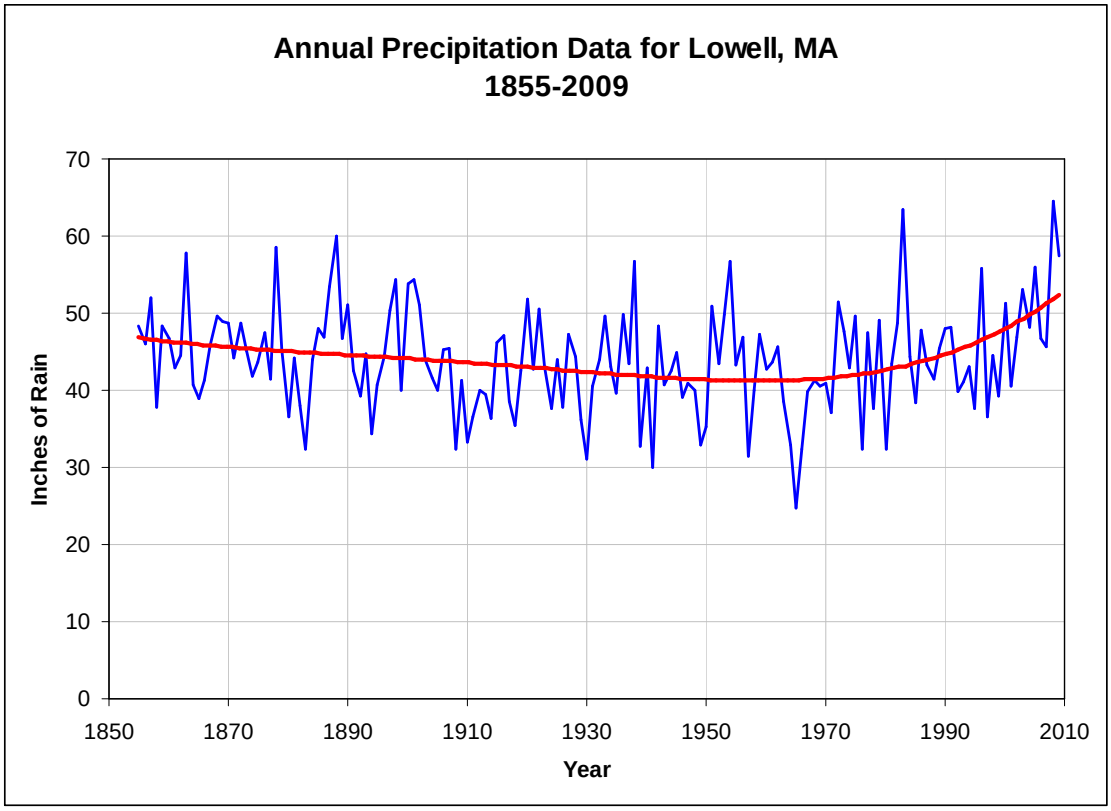
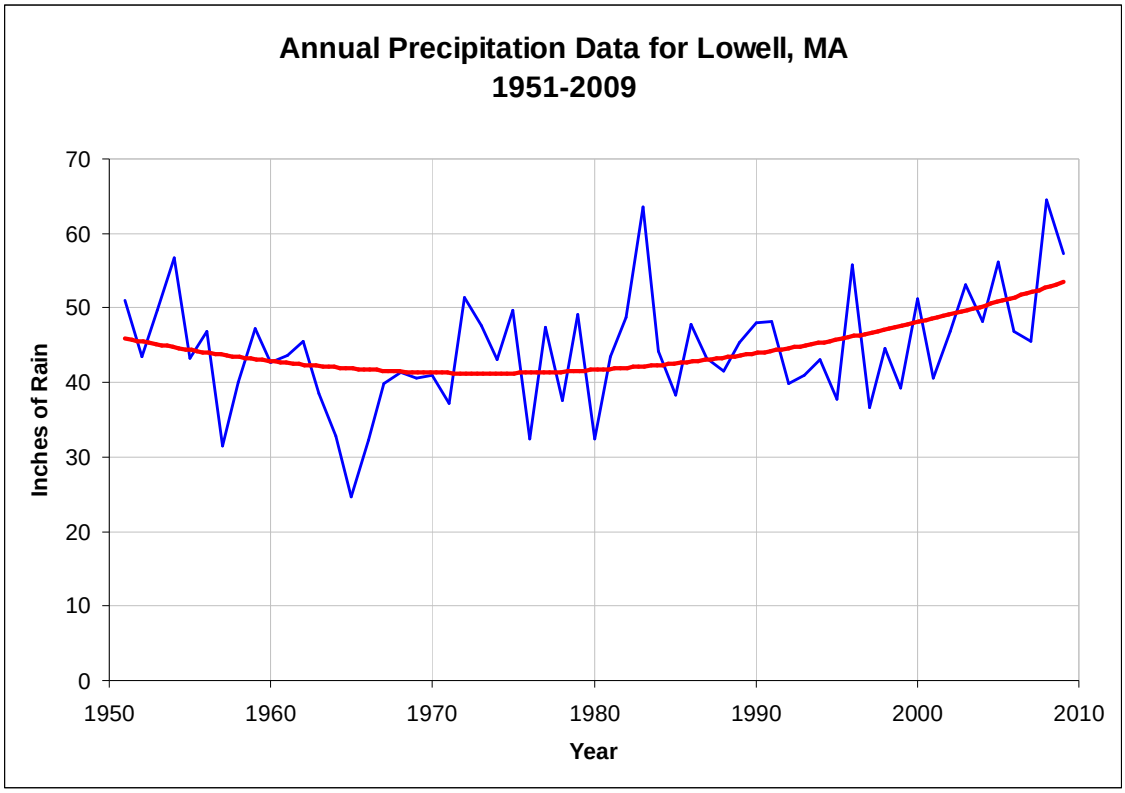


Image Courtesy of U.S. National Oceanic and Atmospheric Administration (NOAA)

Annual Precipitation has increased at varying intervals across different parts of Massachusetts from 1899-2000. The greatest amounts of precipitation occur close to the ocean, with areas such as Boston showing over 8 inches of increase. The trend shows that there has been 11 inches of increase overall in Massachusetts from 1960 to 2010.



This data shows the annual precipitation amounts in Lowell, MA from 1855 to 2009. The trendline is a 3rd order polynomial that shows a marked increase in precipitation amounts in the past 20 years. 2008 was a record breaking year when 64.57 inches of rain fell on the city. The average annual precipitation over these 154 years is 43.98 inches and for the past 8 years, Lowell has gotten more rain than that average.



This data shows the annual precipitation amounts in Lowell, MA from 1951 to 2009. The trendline is a 2nd order polynomial that shows a marked increase in precipitation amounts in the past 35 years. Both of these graphs show there is a steady increase in the amount of rain Lowell has been getting for the past 20-30 years.

Operator "Boot Camp" Outline

- What the historical data predicts will happen in Massachusetts for:
    - Precipitation amounts and intensity
    - Sea level and land erosion
    - Overall average temperature

- How these changes will affect wastewater treatment plants
    - Precipitation will cause more severe flooding leading to possibly exceeding capacity, falling out of regulation and equipment failure. River level rise might impede effluent discharge
    - Sea level and erosion will lead to more severe flooding and impede effluent discharge for some coastal plants. Might also raise groundwater level impeding groundwater discharges.
    - Temperature rise might affect biological treatment processes

- How the operators can act during extreme climatic events
    - Turn on pumps if effluent is not discharging fast enough
    - Assess decisions on a risk/consequence basis. Example: Deciding to have a CSO or SSO for a few hours to protect the plant instead of not overflowing, flushing out the plant and putting it out of commission for weeks or months.
    - Call in outside help such as staff, equipment such as generators, pump or temporary levees
    - Report damages in a timely fashion

- What additional resources are available
    - Massachusetts WARN which connects state utilities to promote exchange of staff, equipment and water connections in times of need. Program is at no cost to the utilities and meets FEMA requirements for reimbursement
    - USGS Water Watch for monitoring water levels in real time
    - NOAA Advanced Hydrologic Prediction Service, also for monitoring water levels in real time
    - Using the SCADA system in your plant to monitor flows and water levels.

Table 6: List of Climate Change Tools

Part 1

Title	Main Affiliate(s)	Description/Purpose
LiDAR modeling on impacts of climate change	MWRA	Unknown
3D Visualization Pilot	Hull, MA / CZM / StormSmart Coasts	Visualization using Google Earth with flood plain and sea level rise overlays
Water Utility Climate Change Awareness and Risk Assessment Tool (WUCCAT)	EPA	Help utilities assess climate change threats, threshold levels for failure and adaptation options
MIKE Software	DHI	Advanced modeling packages for water resources, coast and sea, industry and cities
ClimateWizard	ClimateWizard	Interactive map with projected climate changes in temperature and precipitation
Vulnerability and Consequence Assessment Tool (VCAT)	Seth Tuler, WPI	Flowchart based software that helps communities identify vulnerabilities

Part 2:

Title	Timeframe	Notes
LiDAR modeling on impacts of climate change	Unknown	
3D Visualization Pilot	Completed, report available	Publically available, but not online
Water Utility Climate Change Awareness and Risk Assessment Tool (WUCCAT)	Planned release in Fall 2010	
MIKE Software	Available	
ClimateWizard	Available	www.climatewizard.org
Vulnerability and Consequence Assessment Tool (VCAT)	In testing, planned release Summer 2010	

Suggested Material Outline for Climate Change Adaptation Presentations

- Water Associations
    - How water utilities are at risk from climate change
    - What actions have been done already to help water utilities adapt to climate change
    - How the MassDEP wants to help
    - How the water associations can help

- Plant Operators
    - How water utilities are at risk from increasing trends in temperature, sea level and storm intensity as evidenced by historical data
    - How specific plant operations will be affected
    - What actions can be taken to keep the plant operating within regulation during those events

- Utility Planners/Engineers
    - How water utilities are at risk from increasing trends in temperature, sea level and storm intensity as evidenced by historical data
    - How specific plant operations will be affected
    - How to incorporate these trends in future planning efforts

- Town DPW Officials
    - How water utilities are at risk from increasing trends in temperature, sea level and storm intensity as evidenced by historical data
    - How this will affect the town and community if the utility does not adapt
    - What the town can do to help the utilities

- Public Water Utility Customers
    - How water utilities are at risk from increasing trends in temperature, sea level and storm intensity as evidenced by historical data
    - How this will affect homeowners
    - What they can do to help the utilities

Appendix E – Thank You List

This is the complete list of people that we would like to thank. We appreciate that they found time to be interviewed and help us gather information for our project. We also would like to thank all of the interviewees who requested confidentiality.

Table 7: Thank You List for the People We Interviewed

Name	Organization	DW or WW
David Terry	DEP	DW
Paul Niman	DEP	DW
Edward Kunce	DEP	Neither
Thomas Bienkiewicz	DEP/Board of Certificiation of Wastewater Treatment Plant Operators	WW
Raymond Raposa	NEWWA	DW
Steven McCurdy	DEP	Neither
Rebecca Weidman	NEIWPCC	WW
Daniella Hirschfeld	CZM/StormSmart Coasts	Neither
Eric Worrall	DEP: NERO	Both
Kevin Brander	DEP: NERO	WW
Mike Foisy	MWPCA/UBWPAD	WW
Norman Willard	EPA Region 1	Neither
Jennifer Pederson	MWWA	DW
Eric Willett	Lowell Regional Wastewater Utility	WW
Michael Stuer	Lowell Regional Wastewater Utility	WW
Timothy MacDonald	Walter J. Sullivan Water Treatment Facility at Fresh Pond	DW
Sam Corda	Walter J. Sullivan Water Treatment Facility at Fresh Pond	DW
Steve Estes-Smargiassi	MWRA	Both
John Riccio	MWRA: Clinton WWTP	WW
Paul Cardon	UBWPAD	WW
Thomas Walsh	UBWPAD	WW
Joe Novak	UBWPAD	WW

Appendix F – Summative Team Assessment

When working together as a team we initially established that every team member has their own views and in order to complete the project effectively we had to keep in mind each team member's feelings. By strategizing our work we could identify best practices that could help each member contribute greatly in their area of strength, but also be able to help enhance each individuals gray areas. Communication was the big issue we would have to overcome throughout our 14 weeks working together because each team member was very focused on accomplishing many of our action items, but we all did so in our own ways.

Our initial practice was to identify each others strengths. Adrian demonstrated the qualities of a team leader. He understood initial concepts and was able to relay back the information to the team and sponsors with confidence and accuracy. Matt had a very open minded approach when in meetings, adding many suggestions that expanded the critical thinking skills of the group while keeping the team members on their toes. John demonstrated great writing skills and motivated the team to create documents that that met the quality of his writing contributions, greatly improving the writing skills of all team members. Saul succeeded in engaging audiences such as our sponsors, interviewees, and co workers helping them feel comfortable and free to communicate with us. He was also was able to help target specific details we would need. With these strengths we believed we could overcome many of the teams' challenges to come. If anyone needed help, we knew where to get advice and by working together and teaching each other well, every member benefitted.

In order to maintain organization within the group, the team held a daily meeting within the first 30 minutes of work every day in order to regain our focus. We would begin by summarizing any key events prior to that day and then organize a list of all things to do. This list was broken down and each individual received a portion of work. We each chose the portion we felt comfortable with, and at times we encouraged each other to step up and try and take the most challenging item to see how far we could take it. This was done to ensure that everyone felt like they had an integral role with the project, and that also to let each other know we could back each other up if help was needed. This helped maintain our focus and by maintaining this structure all team members became better organized and were ready to meet the necessary deadlines.

Another strategy was to let each team member take the lead during interviews or sponsor meetings. We wanted the leadership role to be developed within each individual. At the same time this was to make sure everyone felt comfortable with the material and was able to speak clearly about it. At times we split into two groups and interviewed candidates at different locations to make the most of our time. This also helped each team member get a feel for the process. John and Matt showed dramatic improvements by opting to lead at many meetings and interviews and they became more audible during our presentations.