MASSACHUSETTS ENVIROTHON

2012 Mass Envirothon Current Issue

Sustainable Stormwater Management

Background and Strategies for Community Research

The Mass Envirothon Current Issue challenges your team to investigate an important environmental issue as it occurs in your community, to develop recommendations, and to present your findings to a panel of judges at the Envirothon competition.

The 2012 Current Issue Problem will ask your team to identify the highest priority stormwater issues in your community, and to recommend next steps that municipalities and individuals should take toward solutions.

This year, teams are especially encouraged to look for ways that young people can take effective action in their communities on this issue.

To prepare for your presentation, your team should plan to

- Follow the flow of stormwater in your community, and determine the kinds of pollutants it will carry
- Get acquainted with identified local stormwater management issues and the people who work on these issues
- Identify ways that stormwater problems can be reduced, and in particular, ways that stormwater management can be more sustainable.

These pages identify useful resources to begin your research into sustainable stormwater management in your community. You can also find Envirothon workshop presentations introducing stormwater issues at http://www.maenvirothon.org/currentissue.htm.

The following persons provided major help in defining the issue and suggesting topics and resources for this guide:

Debbie Shriver, Mass Watershed Coalition
Heidi Ricci, Mass Audubon and Mass Association of Conservation Commissions
George Zoto, Ph.D., Mass Department of Environmental Protection
Jennifer Steel, Mass Association of Conservation Commissions
Michele Grzenda, Mass Association of Conservation Commissions
Christine Hatch, Ph.D., UMass Department of GeoSciences and Extension, Water Resources & Climate Change
Dick Starkey, Southern New England Chapter of the Soil and Water Conservation Society

Questions? Contact Will Snyder, UMass Extension, at 413/45-3876 or wsnyder@umext.umass.edu

What is stormwater and when is it a problem?

Stormwater is polluted runoff. Stormwater problems vary from community to community, from rural to urban settings, from inland to coastal environments. But essentially the problem involves pollutants washing off the land surface and impairing the quality of surface water bodies. Both water *quality* and water *quantity* are dimensions of the issue.

The problems posed by stormwater depend on a variety of factors:

> ***The nature of the land surface*:** Impervious surface areas – from rooftops to parking lots to compacted soil in lawns and croplands – increases runoff. In urbanizing locations with increasing areas of impervious surface, very little rain water infiltrates and most runs off quickly. Water falling on warm paved surfaces and rooftops can cause thermal pollution when the runoff flows directly into surface waters.
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> ***The kinds of pollutant*:** Land uses of all kinds leave behind pollutants (see below)that are carried into surface water bodies by runoff. Many unprotected land uses are also vulnerable to increased erosion, producing sediments that are carried by runoff to inland and coastal waters. The fact that these pollutants are widespread and their sources are not easily identified gives rise to the term nonpoint source (NPS) pollution. The toxicity and persistence of pollutants, their capacity to bond with sediment, and the compounding effects when combined with other pollutants, are all factors that contribute to the threat they pose to public health and the health of aquatic ecosystems.
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> ***Frequency and intensity of precipitation events*:** Heavy precipitation increases runoff. When rain arrives after a long dry period during which pollutants have accumulated, more pollutants are likely to be carried by stormwater runoff to receiving water bodies.

In a naturally vegetated watershed, ecosystem services work to maintain a healthy quantity and quality of water at no cost to human community budgets. Runoff from rainstorms and snowmelt is minimal. Most precipitation is either taken up by plants or infiltrates the soil and flows as groundwater . Vegetation plays an important role by slowing, absorbing, and transpiring much of the water quantity. Only small amounts flow over the surface and directly into water bodies such as streams, rivers, lakes, ponds, wetlands, and estuaries. There is very little erosion, and many pollutants are filtered, absorbed, and decomposed in the process.

Where human activity becomes a significant element in an ecosystem, these services can become strained. Maintaining water quality and quantity (e.g. for drinking water supplies) requires more human effort and incurs costs for community budgets.

Impact on Water Quality. The pollutants carried by stormwater are as varied and numerous as the land uses in the contributing watershed. They are often grouped into the following categories:

- *Nutrients* - Too much of naturally-occurring nutrients necessary for life, such as nitrogen and phosphorous, can promote harmful algae blooms and aquatic weed growth that deplete oxygen, alter habitat and reduce aesthetic and recreational value, and increase treatment costs for drinking water. Sources include fertilizers and poorly functioning septic systems.

- *Sediments (solids)* – In urban and developing areas, these pollutants can derive from construction operations and highway maintenance. In more rural locations they can derive from erosion associated with agriculture, logging, and gravel mining operations. Sediment suspended in water and deposited on stream and river bottoms can have a wide variety of effects. Sediments fill the interstices of gravel and cobble stream bottoms, decreasing spawning areas for many fish species and habitat for macroinvertebrates, which serve as food for many fish species and for fish spawning. It decreases water column light penetration necessary for some aquatic plants, and in turn food and cover for fish, and in turn human recreational and aesthetic values. Sediments that settle out can reduce flood storage capacity and increase stormwater discharges.

- *Pathogens* - Microbial pollutants are most commonly associated with livestock, waterfowl, faulty septic systems, and improper handling of pet waste. Introduction of disease-causing organisms to surface or ground water can force shellfish bed closures and swimming restrictions, and affect drinking water.

- *Various Toxics* - These include metals, oil, and grease from normal use of automobiles, organic compounds such as pesticides and herbicides from landscaping and agriculture operations, and salt from road deicing and uncovered salt storage. Many toxics can accumulate in the bottom sediments of our inland and coastal waters and will bioaccumulate through levels of the aquatic food chain. Discharges of toxic chemicals also affect the sustainability of aquatic ecosystems when the most vulnerable early life states are unable to mature. All can adversely affect wetland plants and animals and cause human public health risks.

Seldom does one kind of pollution occur in isolation. Usually several kinds are associated with a particular land use, and the combinations create new problems. For example, toxic substances may adhere to sediment particles and thus persist longer in the environment. A change in acidity can lead to increased leaching and toxicity of metals. Stream and shallow lake/pond water temperatures tend to increase from the warming of stormwater runoff as it flows over warm surfaces. This warming, over time, will reduce the oxygen holding capacity of these receiving waters and ultimately affect aquatic life as well.

Impact on Water Quantity. Conventional land development generally means more impervious surface and less infiltration, and thus more stormwater runoff and less evapotranspiration. More than 10% impervious surface in a watershed begins to change the character of streams that drain the area. Medium density residential areas generally have 35-45% impervious cover. A shopping center may have as much as 95-100% impervious cover. As impervious areas increase, streams become "flashy" (prone to flash flooding). Flashiness is characterized by:

- greater runoff velocity and volume produced by each storm
- more runoff in a shorter time period
- increased frequency and severity of downstream flooding
- increased stream channel erosion and loss of streambank tree cover
- reduced groundwater recharge, affecting ecosystem functions and drinking water supplies
- reduced streamflow and lower water tables during long dry spells
- loss of wetlands and aquatic habitat due to lower water tables

A New Factor: Climate change. Global warming, brought on by human activity (carbon emissions), is expected to include an ***intensification of the water cycle as well as increasing temperatures.*** This intensification will mean increased precipitation, changes in precipitation timing (including potential for drought), and more violent storms. In other words, climate change is likely to exacerbate the quantity and quality problems noted above. While catastrophic flooding (such as that generated in New England by Irene in late August 2011) is generally viewed as a separate issue from stormwater management, **many of the solutions proposed to manage stormwater will also buffer the potential for flooding that accompany climate change**.

Sustainable Stormwater Management

Historically, our approach to stormwater management has been to engineer ways to move these large quantities of polluted runoff "away" as quickly and efficiently as possible. The 20th century in particular was marked by large scale, resource and energy intensive projects including urban storm sewer systems and river levees that moved the problems downstream.

As our understanding and appreciation of sustainability grows, our approach to stormwater management is shifting. We are recognizing that, at the proper scale, natural ecosystem services are effective at handling water quantity and quality issues. Sustainable solutions can be both ecologically sound and economically viable. If we treat natural systems well, they can do the work at a lower cost to us.

The term *sustainable stormwater management* is one of many used to describe the practices and techniques evolving to address stormwater issues. Common terms include *low impact development*, *green infrastructure*, and *conservation design*. However labeled, these practices all seek to maintain and use vegetation and open space, reduce impervious surfaces to increase infiltration, optimize natural hydrologic processes to reduce stormwater volumes and discharge rates, and use multiple treatment mechanisms to remove a large range of pollutants.

Sustainable stormwater management involves a variety of systemic, preventive strategies:

- Addressing water quality issues by preventing pollution in the first place
- Addressing water quantity issues as close to the source (where the precipitation falls) as possible
- Recognizing ecological interconnectedness and addressing problems on a watershed basis
- And if we are serious about preventing these problems in the first place, shouldn't reducing carbon emissions also be an essential strategy for sustainable stormwater management?

Government & Citizen Action

In the 1970s the original focus of the Clean Water Act was on point sources of pollution – for example, pipes discharging sewage and industrial waste directly into water bodies. Sources of pollution, and who was responsible, were easily identified. The positive outcomes of these early efforts to control water pollution are a success story of effective government regulation.

In the 1980s, as the Clean Water Act produced results in point source pollution control, studies began to show that nonpoint source (NPS) pollution was also a significant problem. Responsibility for this pollution was much more widespread. NPS pollution originates in a much wider range of activities and land uses, including everyday practices on the individual level such as changing motor oil, applying pesticides and fertilizers to gardens and lawns, and maintaining septic systems. Public awareness and education were recognized as important components of addressing this form of pollution.

Since the 1990s, the work of reducing water pollution has been a combined effort by government regulation and action by voluntary citizen groups, with the two often coordinating their work.

The difficult work of controlling NPS pollution has the potential to be a success story, too, but requires ongoing commitment to education and vigilance by all of us.

Sources of information relevant to stormwater regulation. The US Environmental Protection Agency takes the lead on the government side, providing information and regulation. The Massachusetts Department of Environmental Protection works with EPA and municipalities. There are two major resources for teams to learn about pollution problems and regulation in their communities:

- Stormwater from urbanized MS4 (Municipal Separate Storm Sewer System) communities is regulated by EPA permits issued under National Pollution Discharge Elimination System (NPDES). Municipalities must develop a stormwater management plan in order to obtain a permit to discharge stormwater. The plan provides a way to ensure that best practices are being followed and that problems are being addressed. EPA maintains a website with information on Massachusetts communities regulated under EPA NPDES permitting. This site is a great resource for communities that fall in the urbanized category: http://www.epa.gov/ne/npdes/stormwater/ma.html

- All Massachusetts communities, including those not in areas defined as urban, have a good resource in MassDEP's Massachusetts Watershed-Based Plan. The WBP is an online resource that draws together information from a variety of sources – including Watershed Action Plans, the Nonpoint Source Management Plan**,** MassDEP Water Quality Assessment Reports, Watershed Action Plans, Nonpoint Source Management Plans,

and Total Maximum Daily Load (TMDL)analyses – into a single, comprehensive source on water quality issues, recommended strategies, and resources. The WBP can be used to get an overview of pollution issues, to develop and implement effective water quality remediation activities, and to identify priority assessment and monitoring work down to the level of the subwatershed. The site may be found at http://public.dep.state.ma.us/Watershed/Intro.aspx. For an example of a watershed-based action plan, see http://www.jonesriver.org/getfile/southcoastal/5duxburyjones.pdf

Getting Started on Your Community Research

The following pages introduce four general areas for investigation – **PLACES, PEOPLE, ISSUES, and TOOLS & STRATEGIES** – plus a listing of helpful resource links. To do a good job in your research, your team will eventually need to be acquainted with all these areas. But you can start with any one of them.

PLACES

Where are the surface waters in your community? What watershed are you a part of? What are the land uses that might be sources of nonpoint source pollution in your community? Where are the stormwater conveyance systems, where do they collect water and where do they discharge it? Are there local examples of green infrastructure/LID practices?

Maps

- **Bird's Eye View**. A fun way to start is by flying over your community using http://www.bing.com/maps.
- **Maps of streams and contributing watersheds.** This online mapping tool can draw watershed boundaries from any point on the landscape. If you find a stormwater discharge point you want to study, you can click on this map and get an outline of the land contributing to that discharge: http://water.usgs.gov/osw/streamstats/massachusetts.html
- **Land use changes**. Oliver, the MassGIS online mapping tool at http://maps.massgis.state.ma.us/map_ol/oliver.php can be used to investigate changes in land use at the subwatershed level in your community since 1971 by using the *Land Use* data under *Physical Resources*.
- **Historic topo maps** can be used to identify changes in streams and water bodies and help to trace the route that stormwater may follow. http://docs.unh.edu/nhtopos/nhtopos.htm
- **Maps of storm sewer systems.** New regulations for MS4 communities will require that towns map their storm sewer systems. Some have already done so. If they have, the maps will likely be available through the Department of Public Works (DPW) or the town engineer.
- **Team Maps.** The Massachusetts Executive Office of Energy & Environmental Affairs will provide registered Envirothon teams with two large scale color printed maps of their communities showing stormwater –related information for use in research and presentations at the Envirothon.
- **EPA's Surf Your Watershed**. Not exactly a map, but useful place-based information on the web: http://cfpub.epa.gov/surf/locate/index.cfm

Field exploration

Time to head outdoors, preferably when it is raining or snow is melting so you can see stormwater flow in action!

- First, remind yourself of the reasons to protect water quality. Where does your drinking water come from? Where does your wastewater go (and who is using water downstream)? Where are the most ecologically sensitive areas?
- Follow the flow of stormwater in your community. How and where is it collected in your neighborhood? This Storm Drain Mapping Project Field Manual was designed to help stream teams to identify storm drain outlets in their communities and to assess problems with the stormwater system http://www.mass.gov/dfwele/der/riverways/pdf/stormdrainmanual.pdf

- Become familiar with land uses that may have water quality impact in your community. Here is one example of a survey you can use to be more systematic in your observations: http://www.epa.gov/owow/monitoring/volunteer/stream/ds3.pdf
- Inventory road/stream crossings (you can mark these on your Envirothon map). These intersections can be sites of both water pollution and flooding. Does stormwater from the road travel through a chute to the water body? If so, could water be redirected into a vegetated area where it could infiltrate the soil before reaching the stream? Is there significant sediment buildup from the road?
- Are there examples of Low Impact Development and other sustainable stormwater designs in your community, such as rain gardens, retention basins, pervious pavement, and managed woodlands?

PEOPLE

Talking to people is almost always the best starting place for community research. Watershed advocates and local officials will be good resources because they have responsibilities or special interest in stormwater management. Talk to lots of people! As you get more familiar with the issues and the language that people use to talk about stormwater, it will get easier and easier to ask questions. Start with people you already know by some personal connection. Get them to recommend more people, and follow those leads.

Community groups. Local citizen groups, composed chiefly of volunteers are perhaps the most potent force for environmental protection at the local level. Links to local watershed groups may be found at the websites of the Mass Rivers Alliance at http://massriversalliance.org/member-organizations/ and the state Riverways program at http://www.mass.gov/dfwele/der/riverways/watershed/index.htm . Local land trusts may also be good sources of information (see the Mass Land Trust Coalition at http://www.massland.org/list-of-land-trusts)

DPW workers/managers. These municipal employees are usually very familiar with stormwater-related issues. Start the conversation by asking what they would do first if they had all the resources they needed for stormwater management. Ask them about the frequency of streetsweeping and cleaning of storm drains. Ask how surface waters can be protected from storm drain and road runoff discharges.

Conservation Commissioners. This municipal board (often with assistance from a conservation agent) has responsibility for ensuring that local stormwater management meets Stormwater Management Standards set by MassDEP. The conservation agent is likely to be familiar with the environmental impact of stormwater in your community.

Planning Board members. The decisions of this municipal board directly affect stormwater management in their approval of subdivisions and site development plans that can increase impervious cover. Do their "Subdivision Rules and Regulations" include measures that provide for sustainable stormwater management? Are the board members familiar with low impact development designs?

Energy Committee. Many municipalities now have green committees dedicated to reducing municipal energy costs and educating homeowners about energy conservation and reduction of carbon emissions. Does your community's energy committee appreciate the role that sustainable stormwater management can play in reducing the energy consumption associated with water treatment and repair of flood damage?

County Conservation District Supervisors. These people work with the farm community and are particularly familiar with how to address nonpoint source pollution issues originating in agricultural practices.

Environmental engineers and landscape architects have professional training and experience in the technical specifics of stormwater management and best practices.

Developers, builders, landscape businesses are likely to have perspectives on stormwater management. They frequently have opportunities to implement LID practices.

ISSUES

Many environmental activists get involved for the first time because of a burning local issue that affects them directly. They learn the relevant science and decision-making processes as they go, and usually end up with a much larger, more informed ecosystem perspective.

You may find an issue to get you started by talking with people or reading the local newspaper:

- What water issues are people concerned about? How do these issues relate to stormwater and nonpoint source pollution?
- What development is planned? How might these projects affect the quantity and quality of water in the watershed? Are there sustainable stormwater/LID/green infrastructure practices that could make the development more sustainable?

Below are some topics (and some potential solutions) to be on the lookout for in Massachusetts communities in 2012. This is not an exhaustive list of issues!

Increasing frequency of extreme weather events is consistent with climate change models that predict intensification of the water cycle. More frequent, more extreme weather mean more stormwater.

Best Practices for stormwater management that employ sustainable, low impact approaches mimic natural landscapes. These practices can very effectively address most of the quantity and quality issues that result from the 90% of storm events with less than an inch of precipitation. They can buffer the local effects of climate change by reducing flooding that results from heavy rain events. In drought, they help maintain groundwater levels.

Surface water vs. groundwater protection. While LID practices protect surface water by encouraging stormwater infiltration, what happens when the infiltration happens in an area over a sensitive aquifer that supplies drinking water? What approaches and technologies are most appropriate for different kinds of pollutants in such cases?

Flooding. As the climate changes, past experience can no longer be counted upon for accurate predictions of future floods, from annual spring flow levels to the frequency of catastrophic events. The "100 year flood" might now be expected to occur on average every ten years. How well prepared are our communities, in terms of issues such as hazardous waste storage in homes? Zoning for new development in flood prone areas? Infrastructure (e.g. culvert size) where roadways cross streams?

Snow disposal as well as snow removal can become a significant issue after intense winter storms. Snow plowed from roadways contains sand and salt as well as all the usual pollutants associated with normal automobile use. Piles of snow can block normal runoff flow. Whether the plowed snow is piled on roadsides or transported to "snow farms", or worse, dumped into water bodies, it has the effect of a slow motion flood in terms of the pollution it causes.

The cost of maintaining, repairing, and replacing 20th century stormwater infrastructure, as it strains under the burden of climate change and increased upstream impervious surfaces, can be an expensive burden on 21st century budgets. According to the EPA, stormwater management can be costly, but it is a good investment -- preventing polluted runoff, providing flood control, and increasing groundwater recharge. New England communities have experimented with **stormwater utilities** and other ways to raise needed funds and encourage LID practices: http://www.epa.gov/region1/npdes/stormwater/assets/pdfs/FundingStormwater.pdf

Combined Sewer Overflows (CSOs) are the result of sewer systems that combine storm and sanitary sewers. When heavy rainfall events cause these systems to overflow, raw sewage and polluted runoff are discharged together into water bodies. These systems are found in many urban centers. They are expensive to replace with sewer systems that keep storm and sanitary wastewater separate.

Beach closings are often associated with severe summer storms and the resultant increase in bacteria levels from combined sewer overflows or direct storm runoff.

Fluctuating in-stream flows. Watersheds with large areas of impervious cover can generate large amounts of runoff that runs quickly into rivers and lakes, leaving less water to infiltrate and maintain groundwater supplies that sustain base flows during drought conditions. Such fluctuations in flow are a stress on the ecosystem, particularly aquatic life that depends on moderate stream flow, and can also affect drinking water supplies.

Compliance with EPA NPDES regulation. The majority of EPA and MassDEP regulatory effort takes the form of educating and working with developers and municipalities to ensure compliance with stormwater regulations. However, sometimes these agencies take enforcement action, levying fines and requiring specific remedial actions. How effective are these government agencies at protecting the environment in the case of stormwater and nonpoint source pollution?

TOOLS & STRATEGIES

Sustainable stormwater management requires that solutions be both ecologically sound and economically viable. Fortunately, communities, professionals, and individuals have a variety of tools and strategies available to them that meet these criteria.

Green infrastructure and low impact development strategies have proven not only to be effective at protecting water quality, but also to be dramatically less expensive than traditional stormwater infrastructure. For example LID strategies can reduce energy costs (and carbon emissions) as well as protect water quality, and can reduce stress on existing infrastructure , leading to reduced management and maintenance costs. See http://www.unh.edu/unhsc/forgingthelink. This is true in urban as well as suburban areas. See *ROOFTOPS TO RIVERS: Green Strategies for Controlling Stormwater and Combined Sewer Overflows* http://www.nrdc.org/water/pollution/rooftops/rooftops.pdf. Protection of stream corridors and creation of parks and greenways can also play important roles in providing green infrastructure. See *Green Infrastructure: Protecting and Enhancing your Community's Vital Resources* http://www.massaudubon.org/PDF/shapingthefuture/CPTC_Ryan.pdf

Local government action. Municipal governments are responsible for compliance with EPA NPDES regulations. There are also ways that local governments can be proactive in addressing stormwater issues.

- MassDEP offers advice for local officials on stormwater responsibilities and opportunities: http://www.mass.gov/dep/water/laws/mc_stormw.htm
- The US EPA offers extensive advice for incorporating LID practices into municipal stormwater programs: http://www.epa.gov/region1/npdes/stormwater/assets/pdfs/IncorporatingLID.pdf
- Some municipalities have opted to adopt a stormwater bylaw to provide local procedures and standards for development: http://www.eot.state.ma.us/smartgrowth/07toolkit/LID/regional_planning/LID/Stormwater_Bylaws_LID.html
- The Massachusetts Watershed Coalition's *Community Guide to Growing Greener* is a guidance document that can be adopted by a town planning board. It describes several common low impact practices and planning approaches to reduce and remedy stormwater runoff. Planning boards can adopt it as guidance for developers and residents to show the approaches they wish to encourage in the town. The guide can be downloaded here in pdf format: http://www.commonwaters.org/resources/community-guide-to-growing-greener

Voluntary action. Most stormwater problems are the result of existing conditions and are not immediately affected by regulations, which focus on new development and redevelopment. Voluntary actions by homeowners, businesses, churches, schools, are vital to making a timely difference in water quality from stormwater and reducing flooding caused by runoff. Many LID techniques can be retrofitted into property at very low cost. The obstacle is a

lack of awareness of the problem and a lack of knowledge about simple, beneficial practices that can be implemented by individuals. A number of government agencies and education/advocacy organizations have published guides for educating the public about opportunities for individual and collective citizen action:

- Massachusetts Audubon's *Sustainable Communities Toolkit* provides information for citizens "to help you create, manage and maintain a sustainable community." Stormwater management and water quality is the first issue on the list: http://www.massaudubon.org/shapingthefuture/toolkit.php
- The University of Connecticut's NEMO program offers resources for site developers (http://nemo.uconn.edu/tools/stormwater/) as well as a rain garden design guide for homeowners (http://nemo.uconn.edu/publications/rain_garden_broch.pdf)

Resources

U.S. Environmental Protection Agency (EPA) – a very extensive website:
http://cfpub.epa.gov/npdes/home.cfm?program_id=6

The Massachusetts Watershed Coalition (MWC)
http://www.commonwaters.org/

Center for Watershed Protection
http://www.cwp.org/

Stormwater Manager's Resource Center (slideshows, fact sheets, other resources)
http://www.stormwatercenter.net/

University of New Hampshire Stormwater Center
http://www.unh.edu/unhsc/

Buzzards Bay National Estuary Program > Stormwater Pollution in Buzzards Bay
http://www.buzzardsbay.org/stormwater-pollution.htm

EPA Using Smart Growth Techniques as Stormwater Best Management Practices
http://www.epa.gov/smartgrowth/pdf/sg_stormwater_BMP.pdf

Envirothon workshop presentations relevant to stormwater can be viewed here:
http://www.maenvirothon.org/currentissue.htm

For discussions of climate change and water resources, including impact on stormwater issues, see:

- Northeast Climate Impacts Assessment: http://www.northeastclimateimpacts.org/
- Natural Resource Defense Council (July 2011) *Thirsty for Answers: Preparing for the Water-related Impacts of Climate Change in American Cities* http://www.neiwpcc.org/climatechange/climatechange-docs/thirstyforanswers.pdf
- Massachusetts Executive Office of Energy & Environmental Affairs (Sept 2011) *Massachusetts Climate Adaptation Report* http://www.mass.gov/Eoeea/docs/eea/energy/cca/eea_climate_adaptation_report.pdf
- US EPA's Watershed Academy *The Effect of Climate Change on Water Resources and Programs* http://cfpub.epa.gov/watertrain/pdf/modules/Climate_Change_Module.pdf
- New England Climate web site (UMass Amherst) http://www.cns.umass.edu/neclimate/