Old Colony Planning Council

Climate Change Roadway Drainage and Runoff Study

Prepared by Old Colony Planning Council
70 School Street, Brockton, MA 02301
under MassDOT Contract #0052455

Disclaimer and Funding

The views and opinions of the Old Colony Planning Council expressed herein do not necessarily state or reflect those of the U. S. Department of Transportation.

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This Climate Change Roadway Drainage and Runoff Study was prepared by the following members of the Old Colony Planning Council staff under the direction of Pat Ciaramella, Executive Director, and the supervision of Charles Kilmer, Transportation Program Manager.

REPORT PREPARATION

Andrew Vidal; Communications, IT, & GIS Specialist

avidal@ocpcrpa.org

CONTRIBUTING STAFF

Eric Arbeene, Planner

earbeene@ocpcrpa.org

MAPPING AND GRAPHICS

Susan McGrath, GIS Coordinator

smcgrath@ocpcrpa.org

Andrew Vidal; Communications, IT, & GIS Specialist

avidal@ocpcrpa.org

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Introduction: The Floods of March 2010

From March 13th to 15th of 2010, the Blue Hill Observatory in Milton, Massachusetts recorded a rainfall of nearly seven and a half inches[1]. Two weeks later, on March 29th and 30th, more than four and a half inches of rainfall occurred. Several smaller rain events occurred that March, totaling a record fifteen inches of rain. A state of emergency was declared by Governor Deval Patrick on March 15, and again on the 29th of March[2]. In Brockton, residents were forced to evacuate their flooded homes; in East Bridgewater, parts of Route 18 were closed to traffic. The capacity of the stormwater infrastructure in many parts of the region was overwhelmed.

Sudden intense storm events, such as those in the spring of 2010, cause problems beyond the immediate property damage and threat to public safety. The costs of evacuating residents, tasking police with redirecting traffic, clearing flooded roads, and repairing damage to those roads can be significant to municipalities. While the priority in a crisis situation is the protection of people and property, the impact on the natural environment of the storm event may be neglected. Rising waters will lift and deposit pollutants, wastewater facilities may be inundated beyond their capacity, and sensitive environments may be harmed. Even normal storm events can carry pollution, erode and degrade roadways and infrastructure, and cause sediment to clog drainage.

When the flood waters subsided in April of 2010, Old Colony Planning Council staff asked its constituent communities to document flooded areas. Highway and public works departments responded with lists of affected areas, and these were mapped and discussed in OCPC's Climate Change Transportation Impact Study, released in 2010. This Roadway Drainage and Runoff study intends to build upon the insights gained in this previous study, to explore the potential effects that climate change-related events could have on the transportation network and on the natural environment, and to explore the condition of the storm water drainage network in these problem areas.

This study will connect the potential impacts discussed in the Climate Change Transportation Impact Study with adaptation measures designed to keep our transportation infrastructure functioning properly while enhancing the quality of our valuable natural resources. This study is also intended to contribute to our Environmental Protection and Climate Change Task Force, an ongoing dialogue with regional stakeholders to develop policies, goals, objectives, and performance measures for the Old Colony region.

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[1] *Blue Hill Observatory, "Blue Hill Observatory 2010 Precipitation," www.bluehill.org*

[2] *Abel, David. "Patrick declares state of emergency; R.I. braces for 'life-threatening' flood." The Boston Globe, 29 March, 2010. Internet. Accessed 10 January 2011.*

Section 1: The Interaction of Stormwater with the Human Environment

A Description of the Old Colony Planning Council Region

The Old Colony Planning Council region consists of fifteen communities in southeastern Massachusetts. The region, according to the 2010 US Census, is home to 333,468 people. The City of Brockton and the Towns of Abington, Bridgewater, East Bridgewater, Halifax, Hanson, Kingston, Pembroke, Plymouth, Plympton, West Bridgewater and Whitman are located in Plymouth County. The Towns of Avon and Stoughton are located in Norfolk County, and the Town of Easton is located in Bristol County.

The region spans two vital north/south transportation corridors: Route 24 and Route 3. Brockton is the largest single municipality, with a population of 93,810. The Greater Brockton Area has the highest population density in the region, as well as several major centers of employment.

The center of the OCPC region is mostly low-density residential, as it lacks connectivity to major highways. The construction of the Old Colony Line of the MBTA's Commuter Rail, however, has encouraged growth within this area.

The region has seen significant growth in the east and south in recent years. Plymouth has experienced greater total growth than any other community in the region in the last twenty years, while Kingston has had the fastest growth rate. The extension of the Old Colony Line and the availability of developable land have been major factors in this recent growth.

The Physical Geography of the Region

The physical geography of the Old Colony region is characterized by features left by the period of glaciation ending approximately 18,000 years ago. The Laurentide Ice Sheet that covered much of northeastern North America scoured the land and created many of the geographical features visible today in the region. As the glaciers moved, their immense weight stripped topsoil from the ground and scraped the bedrock. Upon melting, this crushed and ground rock was deposited as a new layer of soil. The number of large boulders that can be found on or below the ground is due to this glacial action. Sandy and loamy soils predominate in the area, the large grain sizes of these soils providing good natural drainage.

The topography of the region is relatively flat, with the exception of the Pine Hills near the coast in Plymouth. Areas of relatively higher elevation exist in the northern communities of Stoughton, Avon, and Abington, ranging up to approximately 250 feet. The lowest elevations are found at the point where the Taunton River exits the region. Although more than 20 miles from the ocean, the elevation is merely 15 feet above sea level. The region's rivers and streams do not experience great or rapid drops in elevation, and generally flow slowly. Many of the rivers are broad and meandering with shallow depths and a wide riparian zone of wetlands along the banks.

The headwaters of several major watersheds of Southeastern Massachusetts originate in the Old Colony region. The Taunton River flows south, draining much of the region's western half. The northern extremes of the region flow into the Weir and Neponset Rivers. The eastern half of the region drains primarily to Massachusetts Bay, by a number of streams, most notably the Jones River and the North River. The western half of Plymouth, mostly covered by the Myles Standish State Forest, drains into the Buzzards Bay Watershed (Figure 1).

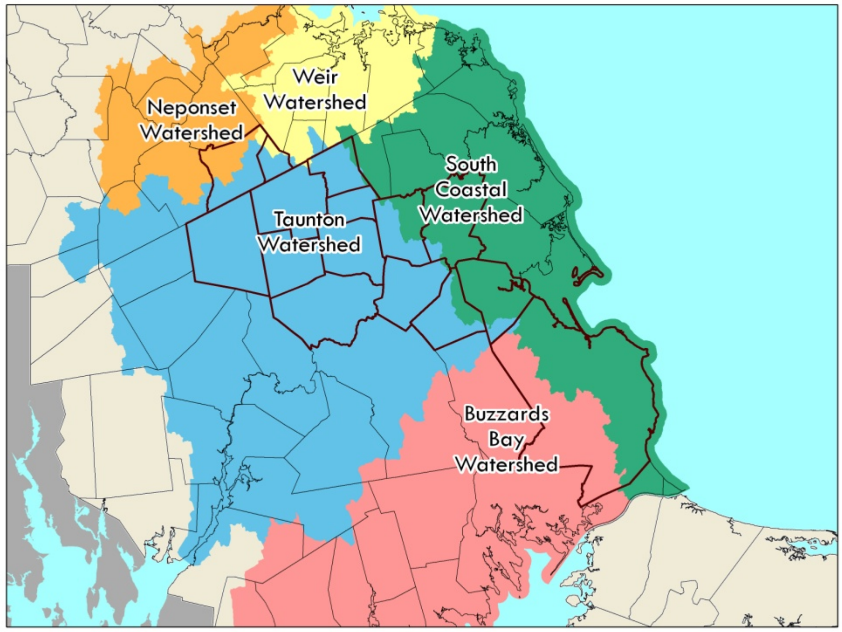

Figure 1: Watersheds of the OCPC Region

The Old Colony region receives between 45-50 inches of rain per year. This combination of plentiful rainfall and flat topography has created a high water table, especially in the center of the region. This high water table is evident in the large amount of surface water in the form of kettle ponds and wetlands. Kettle ponds such as Silver Lake and Monponsett Pond were created by fragments of melting glaciers. Of the 344 total square miles of the region, more than 29 square miles of the region are classified as wetlands, as well as 15.5 square miles of lakes, and a considerable number of cranberry bogs[3].

The Pressure of Development

Human settlement in the Old Colony region dates back thousands of years. The region was predominantly agricultural from the pre-colonial era until the mid-to-late 1800s. In pre-colonial times, agriculture was mainly managed on small plots of cultivated crops. The impact from this type of farming created small, localized impacts on the environment. In colonial and pre-industrial times, however, forested areas were clear-cut for farming. The removal of the treetop canopy and root systems of the trees destabilized the soil, and the freshly plowed fields were easily eroded by rain runoff[4]. This eroded soil was transported to rivers and lakes, causing increased turbidity, decreased growth within the water bodies, and sedimentation.

Rivers were faced with new threats when New England began to industrialize in the late 1800s. Dams were constructed on many waterways to create power for factories. While this source of power allowed Massachusetts to become a powerful manufacturing economy, it also had the effect of blocking the

[3] *Determined using the MassGIS Hydrography (1:25,000) layer, clipped to the OCPC region.*
[4] *Harvard Forest. http://harvardforest.fas.harvard.edu/museum/conservation.html*

passage of anadromous fish from the ocean to their upstream breeding areas, resulting in food chain disruptions and loss of species biodiversity. Many of these dams and the ponds they created still remain today. Also, industrial pollutants that had not existed before were now deposited in waterways. For example, the City of Brockton became a leader in shoe production and many factories disposed of chemicals from the leatherworking process into local streams.

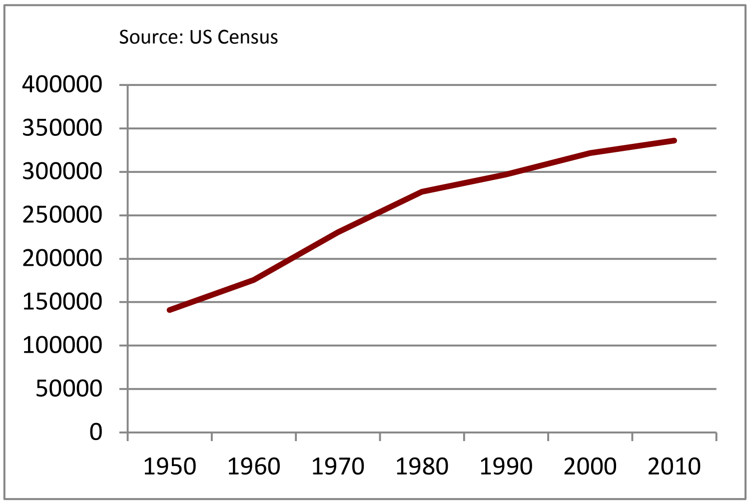

Figure 2: Population Growth in the OCPC Region (1950-2010)

The rise of an industrial economy and the decline of agriculture had varying effects. Some farms lay fallow and reverted to new growth forest, thus reducing the amount of erosion and pollution from farmland. However, a burgeoning population in the post-war period increased the demand for housing. The nation's new prosperity allowed people to move from the cities to the spacious suburbs, where population density dramatically decreased.

In the post-war years, most growth occurred in the suburbs. Some towns, such as Easton and Whitman, already had small centers based around a few factories. Other towns, such as Halifax and Plympton, had very small populations and few clear centers of activity until recently. Towns like West Bridgewater, Bridgewater, Plymouth, and Kingston, which previously had been small towns, were now located along superhighways. This encouraged the construction of housing and related amenities in these towns. Over time, this suburban sprawl development has extended through nearly the entire region. Accordingly, the population of the region has grown steadily, as shown in Figure 1.

Table 1: Impervious Surface in OCPC Communities. *Source: EPA*

Community	Area (Square Miles)	Impervious Area (Square Miles)	Percentage of Impervious Surface
Abington	10.17	1.77	17.42
Avon	4.54	1.08	23.72
Bridgewater	28.41	3.32	11.69
Brockton	21.55	7.68	35.63
East Bridgewater	17.55	2.04	11.62
Easton	29.23	3.09	10.57
Halifax	17.36	1.28	7.36
Hanson	15.72	1.58	10.02
Kingston	18.98	2.66	14.04
Pembroke	23.55	2.65	11.25
Plymouth	102.63	10.51	10.24
Plympton	15.07	1.10	7.32
Stoughton	16.45	3.00	18.23
West Bridgewater	15.67	1.61	10.30
Whitman	6.95	1.33	19.20
Total	343.83	44.70	

In many towns, sprawl development was codified in zoning by-laws. Large lot requirements in new subdivisions, clear-cutting trees at construction sites, and wide roads with low traffic volumes all have an impact on the hydrologic system. Despite the growing acceptance of smart growth concepts and the incentives of higher-density development legislation such as Chapter 40R, this sprawl-type development has continued in many parts of our region up to the present.

The rapid increase in the use of automobiles during this period of growth has necessitated the construction of numerous asphalt roads, which are nearly 100 percent impervious to the penetration of water. Today, roads, parking lots, structures and other impervious surfaces cover thirteen percent of the land in our region. This is not uniform throughout the region; impervious cover ranges from as low as seven percent in the semi-rural towns of Plympton and Halifax, to as much as 35 percent in the urban area of Brockton, as shown in Table 1.

These roadway surfaces affect not only the quantity of water that is delivered to local streams, but the quality as well. Runoff from road surfaces contains a variety of pollutants, from motor oil and gasoline, to particulate matter from asphalt and tire wear, to de-icing salts. Untreated runoff entering streams can introduce these pollutants into the food chain, and can potentially cause harm to animals and people who use the stream.

The Effects of a Storm Event

The natural environment responds differently than does the built environment to storm events. A typical natural setting in southeastern Massachusetts, untouched by human development, would likely be composed of deciduous forest, rocky and loamy soil, numerous small streams, and a landscape of small hills and flat plains. During a rainfall event, the force of the falling water is broken first by the leaves of the trees, by branches, by leaves blanketing the ground, or by grass. When the precipitation reaches the ground, about half of the water is absorbed immediately into the soil. When the ground becomes saturated faster than it can absorb additional amounts of water, the water begins to flow along the ground, gravity drawing it to the lowest point. This water accumulates into small feeder streams that flow into larger branches, ultimately reaching a major river, body of water, and finally the ocean. This process can takes some time depending on the slope and roughness of the ground.

In contrast, when there is a rain event over a developed area, much of that rain falls on rooftops, roads and parking lots. These structures are virtually impervious and have been engineered to expedite the removal of standing water on the surface. The relative smoothness of paved surfaces and building rooftops conveys the water quickly to drainage mechanisms.

Since little to no ground infiltration is occurring, the amount of water on the surface may now be twice as much as normal. In the ground, water moves slowly through the interstices between soil particles, traveling below the surface to nearby bodies of water. This process is slow, reducing further the rapidity with which stormwater is introduced into a stream. Additional negative effects of impervious surface include the lowering of the water table, as the impervious surface creates a hard shell over the ground, and the loss of the natural filtration that the soil provides. A one-inch rainfall event over the City of Brockton would deposit approximately 375 million gallons of water. Since more than one-third of

Brockton is impervious surface, at least 60 million gallons that would have been absorbed into the ground are instead quickly transported to streams.

Since the constructed drainage structures move stormwater away more efficiently than natural processes, they also discharge stormwater into rivers at a greater rate. Depending on the duration and intensity of the event, stormwater falling over a natural environment may traverse uneven soil or collect in puddles, delaying its introduction into a stream channel. Stormwater flowing over pavement or through concrete or steel pipes has far fewer obstructions, and so water reaches the channels in greater amounts for a shorter duration. This quality of stormwater drainage is referred to as flashiness[5].

In places where development is dense, rivers are often channelized so that building construction can proceed up to the river's edge. Concrete or stone walls take the place of natural riverbanks. In a flood scenario, the water normally would spread along the flood plain as it rises. In a channelized stream, the river's increased volume has nowhere to go but up and cannot spread along the flood plain. Salisbury Brook and Trout Brook in Brockton are channelized as they flow through Brockton. Although they are located close to the watershed divide and therefore do not have large collection basins, they tend to rise swiftly even in modest rainstorms.

These greater amounts of water entering the channel increase the erosive power of the stream. This can strip soil from unchannelized banks of the river, widening the channel. The walls of the stream channel may collapse, putting roads and property at risk. This erosive power was demonstrated clearly during the March 2010 floods near the Bridge Street Bridge in Bridgewater. The floods, overflowing their banks and moving very swiftly, undermined the base soils of the roadway. The road partially collapsed, and has been closed since. Figure 3 shows the bridge during the flood, and Figure 2 shows the bridge in the summer of 2011 at a normal water level. The collapse of the road surface took place south of the bridge, at the left side of the image. Figure 4 illustrates the damage to the roadway.

Erosion, besides destabilizing the stream banks, increases the amount of suspended particle matter in the water column. This cloudiness or turbidity of the water blocks light from penetrating. Plant species below the surface of the water, deprived of sunlight, may perish. This can affect other species that depend upon these plants for food. These food chain disruptions can impact land-based species as well, if they are reliant on water-based species for food.

Sediment suspended in the water will begin to precipitate out when the velocity and turbulence of the water ceases. This process is most often visible in the creation of deltas. When a river enters a larger body of water, the forward motion and turbulence of the water, which was keeping the suspended solids afloat, lessens. Very large rivers like the Nile and the Mississippi have extensive deltas that are hundreds of miles across, comprised of sediment that was eroded upstream and brought to the mouth of the river. No rivers in the Old Colony region have the erosive power and size of these rivers, but erosion and sedimentation can present problems even still.

[5] *Hollis, G.E. Rain, Roads, Roofs and Runoff: Hydrology in Cities. Geography, 1988, pg 9-18.*

Figure 3: Bridge Street Bridge, Bridgewater, March 2010.

Figure 4: Bridge Street Bridge, Bridgewater, July 2011.

Figure 5: Bridge Street collapsed section

Undersized culverts can capture sedimentation. The flow of the stream is constricted when it enters the culvert, backing up the water upstream. The upstream flow rate decreases, and suspended particles fall out of the stream at this point. This sediment can block the culvert further, causing more sedimentation. Concrete pipe culverts can easily become choked off, their openings partially buried in sediment. At this point, their function is greatly reduced and even a small amount of stormwater will generate flooding as the water seeks an alternate route downstream. The OCPC region has a great number of these culverts; since most of the area's streams are only a few inches deep, most roadway crossings were engineered to transport a small amount of water.

The damage caused by these stormwater problems can have a harmful impact on all living things that depend on the body of water; this can be compounded by poor water quality. Much of the water running off of impervious parking lots and road carries contaminants such as organic matter, heavy metals, motor oil, road salts, and litter. Many substances used in the normal operation of a vehicle – coolant, oil, gasoline – can easily leak or be spilled and have a severely detrimental impact when introduced to the natural environment. Miniscule fragments of worn tires, as well as bits of asphalt, can also be contained within runoff.

Runoff from lawns and agricultural areas may contain high concentrations of potassium, nitrogen and phosphorus, which are the byproducts of many fertilizers. Sewage treatment plants may also discharge nitrates and phosphates into streams. These nutrients aid in the excessive growth of certain plants, a process called eutrophication. Algae in particular grow well in such nutrient-rich environments, and will multiply at the expense of other plant life in the stream. The algae use a great deal of oxygen as well as reducing the amount of light penetrating the water column, so other plants are unable to carry out photosynthesis. This loss of plant life in the stream impacts the animal species that feed on these plants.

Probably the most characteristic form of agriculture in the OCPC region is the cultivation of cranberries. Unlike other types of crops, cranberries are grown in bogs, directly in contact with the stream network. Pesticides and fertilizer can easily be transported to nearby streams and ponds. Older bogs tend to be constructed so that a stream runs through the center. In this case, there are no controls to keep pollutants from entering the stream network. Newer bogs are usually constructed near, but not integrated with the stream network. Water is diverted from a main channel into small ditches to feed the bog, and thus pollutants can be contained.[6] The Old Colony region has many bogs of both designs.

The region faces many challenges in the future to expand while limiting the impact on the natural environment. Many of the region's streams have been subjected to erosion, sedimentation, and pollution, while development of residences, commercial areas, and paved surfaces continues. Often, these impacts are a secondary concern compared to the development needs of a community. Approaching this issue on a regional scale allows us to see the impacts that cross town boundaries and to devise region-wide solutions to comply with forthcoming EPA legislation.

[6] *Buzzards Bay National Estuary Program. http://www.buzzardsbay.org*

Section 2: Regional Drainage Analysis

In the spring of 2010, the Old Colony region experienced the wettest spring recorded in Massachusetts. Two separate storms totaling one foot of rain fell in March, along with several other minor storms. Rivers overflowed their banks, flooded backyards, and undermined roadways. In some neighborhoods, roads were closed and homes were evacuated. Although there was no loss of life and damage was relatively minor compared to other locations in Massachusetts and Rhode Island, the storms revealed the vulnerabilities of this region's infrastructure to increased severe storm events.

Old Colony Planning Council was, at the time of the storms, already engaged in a Climate Change Transportation Impact Study. The scope of the project at that point was expanded to encompass these events. Public Works, Police and Fire Departments were contacted to collect information on which areas of towns had flooded. No flooded locations were reported for Abington and Avon. This was not unusual, as these towns are located at the head of the region's watersheds. Downstream towns, such as East Bridgewater received water collected from a much wider area, and consequently experienced greater flooding. Several locations within Brockton also experienced flooding, since in many cases the streams have been channelized with concrete walls, and development has proceeded up to the edge of the river.

These flood locations were digitized by OCPC GIS staff as part of the Climate Change Transportation Impact Study. They served as the starting point for the Roadway Drainage and Runoff Program. Along with these higher-risk locations, an inventory of all existing roadway crossings over water bodies was created.

OCPC staff created a geodatabase containing a hydrologic feature class for the entire region. The MassDEP Hydrography (1:25,000) layer and the Networked Hydro Centerlines layers were downloaded from MassGIS as a reference. Both of these datasets were created at a 1:25,000 scale, which is adequate when viewing from a state or county level, but less detailed when viewed at a town level or smaller. To create as accurate a hydrologic layer as possible, OCPC staff digitized a Rivers and Streams layer at a 1:1,000 scale, using the 2008 USGS orthophotos downloaded from MassGIS as a reference. This larger scale makes visible the numerous tributary streams, channels through wetlands, cranberry bog channels, and constructed drainage channels throughout the region.

The resolution of the orthophotos is 30 centimeters, or nearly one foot, per pixel. This resolution does not permit the viewer to finely discern individual objects on the ground, but the flow patterns of river networks are still visible. The criteria for inclusion of a stream into the feature class were developed by using visible water features from the orthophotos, visible water features from other geographic imagery such as Pictometry or Google Street View, streams that were mapped in the Networked Hydro Centerlines layer, and local knowledge by OCPC staff.

In most cases, the stream network was digitized in an upriver direction to the source. An effort was made to link the streams by the most logical routes dictated by the topography, although gaps still exist where the course of the waterway is not clearly discernable. This has occurred where streams are diverted underground in pipes, are intermittent, or are obscured from view by tree cover. In these cases, an attempt was made to find the most logical course for the river, where it was known to exist. In cases where the stream was channeled below ground through culverts or pipes, the stream was assumed to be a straight line and denoted in the database as a culvert. In cases where visibility was obstructed, this was accomplished by using the MassGIS Elevation Contours (1:5,000) layer with 3-meter intervals to determine the most likely direction of flow.

In addition to the Rivers and Streams feature class, the geodatabase also includes a Lakes and Ponds layer that is in progress. This feature class is being digitized at the same 1:1,000 precision.

Using the streams shapefile and MassDOT's Road Inventory, a listing of all road and rail crossings over bodies of water was created. From this list, locations were selected and site visits were undertaken. During these site visits, measurements and observations were recorded on a field data sheet created by OCPC staff (see Appendix). Among the locations were stone arch bridges, wooden pile bridge and concrete culverts, of all ages, and in urban, suburban, and rural areas. By observing a cross-section of locations that were known to have flooded, OCPC hoped to identify several key factors that either produce or exacerbate flood conditions.

Areas of Concern

The Matfield River in East Bridgewater in particular was reported to have flooded in many locations in March of 2010. East Bridgewater has substantial areas of floodplain owing to its flat topography and location at the confluence of several streams drawing from a large collection basin (see figure 5). The runoff from Brockton, Whitman, and Abington all contributed to the Matfield's flow. The flood spilled into the roads, despite the fact that the roads at some locations are as much as 10 feet above normal water levels.

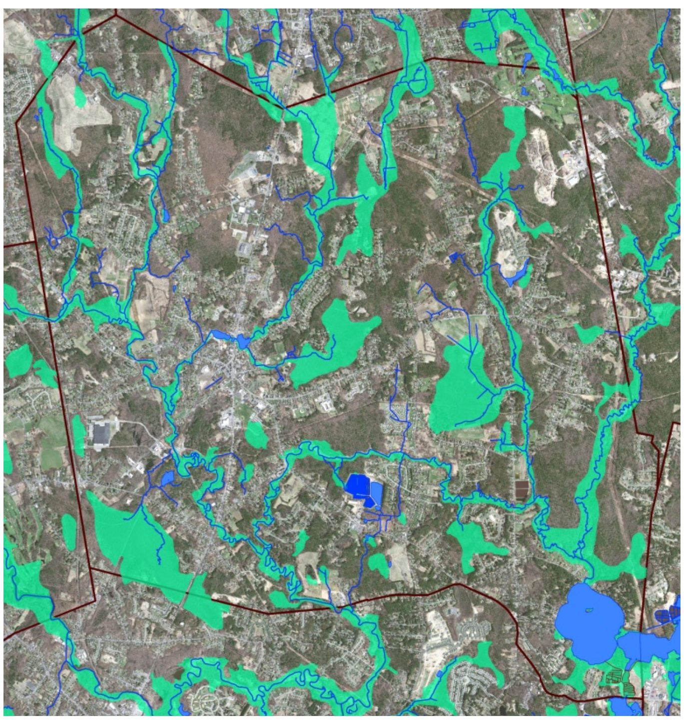

Figure 6: 100 and 500-year flood zones in East Bridgewater

The Matfield floodplain is not heavily developed, but important regional roads, Routes 18 and 106, pass through some of the lowest areas. One crossing, the Corporal Gordon M. Craig bridge at the intersection of Bedford Street (Route 18 and 106) and Whitman Street (Route 106), also flooded during a rain caused by the remnants of a tropical storm in October of 2005. Routing regional traffic around these blockages can add greatly to traffic congestion and travel time, as both routes carry a large number of automobiles daily.

Figure 7: The Salisbury Brook overflowing near Pleasant Street (Route 27) in Brockton, March 2010.

Other hard hit areas in March of 2010 include a section of northwest Brockton, near Route 27. The upper reaches of the Salisbury Brook flow from the ponds at D.W. Field Park into a channel traveling through dense residential neighborhoods. The problems affecting this location are due to high amounts of runoff from the surrounding area. The Westgate Mall, a nearly 200-acre mall complex, drains into nearby ponds and streams and is then fed into a concrete-walled channel traversing the city.

The following series of maps profiles the major rivers and tributaries of the region, and how each river's unique characteristics may affect stormwater drainage.

Section 3: The Response to Stormwater Issues

Stormwater Regulation

The long history of settlement and population density of the northeast United States has had a profound impact on the quality of rivers. No major stream in our region has escaped damming, industrial pollution, sedimentation, erosion, channelization, or the introduction of invasive species. For decades, these problems went unaddressed due to a lack of environmental legal protections, general lack of awareness of the consequences of such actions, and cultural values regarding the nature of progress. By the time that protections were enacted, many streams and the fish from them were unfit for human use.

By the late 1960s, water quality in American waterways was severely degraded. The 1969 Cuyahoga River fire in Ohio, in which oil slicks and trash floating on the surface of the Cleveland area river caught fire, attracted national attention to environmental problems. This event was one of the more dramatic environmental calamities that galvanized governmental agencies into creating water quality legislation.

In 1972, Congress passed the Clean Water Act[1] which was an extensive expansion of previous water pollution legislation. Under the Clean Water Act (CWA), the US Environmental Protection Agency was given the responsibility of managing the National Pollutant Discharge Elimination System, or NPDES. Under the NPDES program, producers of point source pollutants were required to have permits to discharge pollutants to surface water bodies. Point source pollution is pollution that is generated within a localized extent and discharged at geographically proximate locations. Examples of point source polluters can include such places as industrial facilities, farms, and vehicle maintenance facilities. The EPA maintains a list of sites subject to regulation, known as the Facility Registry System. Residences are not considered point sources if they use a septic system or are connected to a municipal separate storm sewer system (MS4). In most cases, the EPA authorizes the states to administer the NPDES program; however, in Massachusetts it is directly administered by the EPA[2].

The aim of NPDES Phase I was to target the most egregious point sources of pollution. Municipalities with populations of greater than 100,000 require a permit, as well as construction activity covering more than five acres and certain categories of industrial activity. While this program saw the reduction of pollutant loads in many rivers, it neglected to tackle nonpoint sources of pollution, most notably urban stormwater runoff.

Phase II of the NPDES program, proposed in 1998, sought to cover small MS4s in urbanized areas. Nearly the entire Old Colony region is located within Census-designated urbanized areas, and thus operators of small MS4s must meet the six minimum control measures (MCMs) of the Phase II regulations. Most of the operators of small MS4s within the region are municipalities; there are, however, several institutional operators of MS4s, as listed in Table 2.

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[1] *http://www.epa.gov/regulations/laws/cwa.html*

[2] *US EPA Storm Water Phase II Compliance Assistance Guide.*

Table 2: Small MS4s in Old Colony Region
Town of Abington
Town of Avon
Town of Bridgewater
Bridgewater State University
Bridgewater Correctional Complex
City of Brockton
Massasoit Community College
VA Healthcare – Brockton
Town of East Bridgewater
Town of Easton
Town of Halifax
Town of Hanson
Town of Kingston
Town of Pembroke
Town of Plymouth
MCI Plymouth
Town of Stoughton
Town of West Bridgewater
Town of Whitman

Due to the large number of municipalities in Massachusetts within urbanized areas, operators of small MS4s can obtain coverage under a general permit. Four general permits have been issued for regions of the Commonwealth: the Northern Coastal Watershed, Southern Coastal Watershed, Merrimack Watershed, and Interstate South-Flowing Watershed. These are not true watersheds, but designated regions of the state for permitting purposes. The Old Colony region is almost entirely located within the South Coastal Watershed, with the exception of Stoughton which is in the North Coastal Watershed. The town of Plympton has been excluded from the region since it did not meet the criteria for an urbanized area in the 2000 Census; however, there has been growth within the non-urbanized areas of the region, and these boundaries may change as a result.

A Phase II permit was issued in 2003 and expired in 2008. Currently the EPA has assembled a draft permit for both the Northern and Southern Coastal Watersheds, and has held a public comment period. According to the EPA's website, the final permit was expected to be available in 2011. Many of the procedures to be followed for this re-issuance of the permit are similar to those of the 2003 permit. For communities to obtain coverage under the general permit, a Notice of Intent (NOI) must be submitted by an MS4 operator within 90 days of the effective date of the final permit, upon receipt of which the EPA authorizes the discharge of stormwater.

The NOI for 2011 permits requires additional information from municipalities on the status of their Stormwater Management Program (SWMP). For the 2003 permit, MS4 operators were tasked with formulating a plan for reducing the impact of stormwater pollution. This plan must illustrate how the town will implement the six minimum control measures (MCMs) specified by the EPA. The six measures are Public Education and Outreach, Public Participation and Involvement, Illicit Discharge Detection and Elimination, Construction Site Stormwater Runoff Control, Stormwater Management in New Development and Redevelopment, and Pollution Prevention.

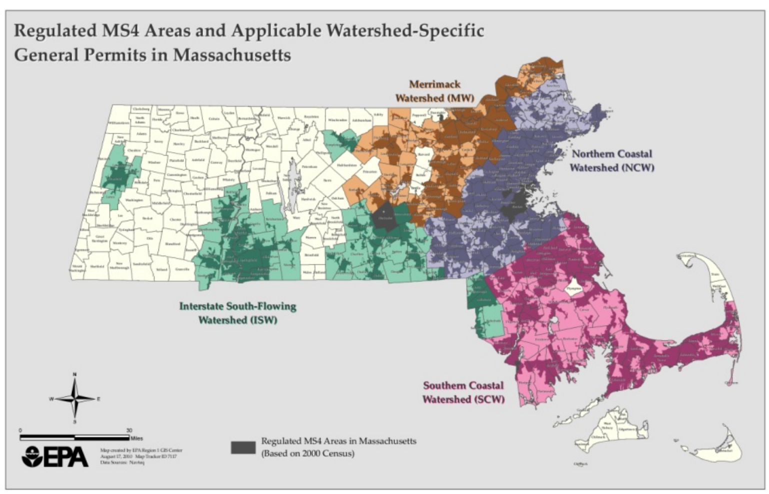

Figure 8: Map of permitting regions in Massachusetts. Source: EPA

The first two of these MCMs require towns to communicate the message of what they intend to do, and how they intend to accomplish it. Municipalities may choose to use local public access, local newspapers, or educational brochures at town offices to disseminate information about the need for stormwater pollution prevention, the steps the town must take, and how citizens and local stakeholders can be involved in the process. The public can give input into the SWMP at hearings, which may then be incorporated into the SWMP. An annual progress report assessing the town's compliance with the conditions of the permit is mandated by the EPA, and should be made publically available.

The third measure is the implementation of an Illicit Discharge Detection and Elimination Program (IDDE). An IDDE program requires municipalities to identify and remove non-stormwater discharges to receiving waters. The illicit discharges of greatest concern are sanitary sewer overflows. A variety of causes, such as heavy runoff or a blockage, can cause untreated sewage to spill and be transported into waterways. The EPA requires that municipalities inventory all overflows and report them. According to the regulations, illicit discharges must be eliminated or enforcement action taken against the polluter within six months of the detection of the discharge. A defined procedure and measures of success must be defined, and an annual status report submitted that details the progress made on the IDDE.

A further requirement of the IDDE is a map of the MS4. This map was required under the 2003 permit, and is now required to be completed within two years of the issuance of a new permit. The map must contain catch basins, pipes, outfalls, and receiving waters, but the EPA also recommends the inclusion of many other sources of data such as the age of infrastructure, locations of suspected illicit discharges, and water table fluctuations. The complete requirements and recommendations of the IDDE Program can be read on the Draft Permit available on the EPA's website[3].

The next minimum control measures regulate runoff from new construction and redevelopment activity. New construction is probably the greatest source of erosion and sedimentation for most communities, and this MCM requires enacting legally enforceable ordinances to control runoff from such sites. This MCM directs municipalities to mandate construction best management practices (BMPs) for developers and to consider implementing Low-Impact Design solutions, which will be discussed in the next section.

For the final MCM, Good Housekeeping and Pollution Prevention, municipalities monitor their progress and take measures to ensure that stormwater infrastructure is managed in an efficient manner. Regular inspections of catch basins, identification of frequently clogged catch basins, and effective operations and maintenance procedures can reduce the impact of pollutants and also reduce the future costs of compliance with stormwater regulations. To fulfill the requirements of the permit, municipalities must develop and document procedures for maintenance of stormwater infrastructure, salting and sanding of roadways in winter, and cleaning catch basins, streets, and parking lots.

[3] *http://www.epa.gov/region1/npdes/stormwater/ma/MIMSC-DraftGeneralPermit.pdf*

Strategies to Mitigate Stormwater Impacts

A growing recognition of stormwater impacts has led to the development of engineering practices that are designed to minimize environmental damage, mimic natural processes, and at the same time interfere as little as possible with a site's intended use. Traditionally, stormwater solutions have focused on removing stormwater from a location as quickly as possible, with little concern for water quality or downstream effects. Water would be collected in a network of pipes that would discharge, untreated, into a body of water. The emphasis on centralizing the water and disposing of it rapidly neglected to take into account groundwater recharge, filtration, and the problems of scaling such a system to the amount of development we have today. Many commonplace development practices, like wide streets in residential areas or large swathes of pavement at shopping malls, created unforeseen problems that Low-Impact Design (LID) techniques attempt to remedy.

Low-Impact Design attempts to work with the natural course of drainage as described in Section 1. Whereas traditional drainage utilizes large stormwater management systems to process stormwater, LID uses a diverse set of water controls designed to simulate the natural hydrologic cycle and reduce the total amount of runoff, distribute and discharge it to more locations, provide better natural pollution controls, and conceal the functionality with aesthetically pleasing design. Low-Impact Design also can refer to measures taken that are not structural in nature, but amend regulations and behaviors to achieve LID goals. The following are some low-impact design practices that are commonly used.

Figure 9: An example of a swale, with overflow storm drains

Figure 10: Water Street Rain Garden, Plymouth.

Swales are low-cost LID measures to increase groundwater recharge and filter stormwater. Swales, or bioswales, are simply shallow depressions in the ground covered with grass or other vegetation. Stormwater that collects in a swale slowly infiltrates the soil, rather than being rapidly carried to receiving waters. This slow percolation into the soil allows silt to settle and pollutants to be filtered out, and can be used effectively to remove pollutants that may lead to eutrophication in lakes and streams, like phosphorus and nitrogen.

A number of other LID practices rely on similar processes as swales, although they vary in their uses. Bioretention ponds and rain gardens also use vegetated depressions to collect stormwater. Bioretention, however, will use specially selected plants and amended soils, which are soils with added materials that improve its pollution absorption or water-carrying capacity. Bioretention also achieves the goals of delaying runoff and increasing recharge. These types of LID practices are most useful in low to medium-density areas, as they take up more space than other types of low-impact design. The Town of Plymouth has constructed a rain garden on a grassy area near the waterfront on Water Street, as seen in Figure 9.

Figure 11: Tree box along a highway.

Tree boxes are similar in function to bioretention, but are more convenient for urban and high-density areas where space is at a premium. Roadway runoff can be directed into a tree box rather than a storm drain, which performs the same filtration function as a bioretention basin. Beneath a tree box, the filtered stormwater may connect to a traditional drainage system. Tree boxes are a scalable solution to low-impact design, as even one can incrementally improve the LID characteristics of a site, while several may be able to replace traditional drainage. Tree boxes have the added benefit of being aesthetically pleasing, and in urban environments can be used to provide a barrier between pedestrians and vehicle traffic.

Pervious pavement or porous pavement is made of coarse grained material so that interstices or voids exist throughout the pavement while it maintains a hard, flat surface. Stormwater thus flows freely through the pavement rather than running off. An area paved with pervious pavement typically covers a stone reservoir designed to retain water while it percolates into the base soil. While it lacks the strength to carry heavy vehicles, it can easily hold the weight of pedestrians and bicycles and can therefore be used on footpaths and sidewalks, and even as parking for lighter vehicles.

Where an accumulation of stormwater cannot be reduced, it may be sequestered. Rainwater harvesting refers to the collection of roof runoff in storage tanks, where it then may be used for other purposes. Roof runoff is typically “gray water”, meaning that it not clean enough to be considered potable, but may be used for tasks such as watering plants or flushing toilets. Roof runoff may also be retained in a rooftop garden known as a green roof. Large flat roofs, commonly seen in commercial development, is produce large quantities of roof runoff and so are ideally suited to green roofs. A notable example of this in the Old Colony region is the Swedish retailer Ikea's store in Stoughton, which in 2005 had a 21,376 square foot green roof constructed on their new store[4].

This is not a comprehensive listing of LID practices, but is meant to demonstrate how low-impact design endeavors to minimize disruptions to the natural movement of stormwater, decrease the effects of impervious surfaces, increase groundwater recharge, decrease the rate of water entering streams, and improve the quality of water bodies.

Low-impact design, however, does not always require the construction of new infrastructure; there are other, more passive measures that can be used to reduce stormwater impacts. Simply decreasing the amount of impervious surfaces or reducing lawn sizes can result in much less runoff or fertilizer pollution, respectively. Proper maintenance and upkeep of stormwater infrastructure can also be crucial to the performance of stormwater best management practices.

Various methods to reduce the amount of impervious surface can be worked into a community's by-laws. Often, developers are mindful of providing a minimum amount of parking or a minimum width for a roadway, leading to unnecessarily large or wide paved areas. Two example locations in our region are shown at the same scale in Figures 11 and 12. Figure 11 shows Bay Road in Easton, which carries 4,600 vehicles daily, with a speed limit of 40 miles per hour, and is 25-30 feet wide; Figure 12 shows a road through a development of 45 houses which carries mostly local traffic, yet the road is 35 feet wide. This excess paved surface, which could be reduced without negatively affecting the users of the road, generates more stormwater, as well as consuming valuable land area and costing more to maintain. Communities can benefit from defining a maximum roadway width based on the projected traffic of a new development.

Figure 12: Bay Road, Easton.

Figure 13: Fairfield Drive, Easton.

[4] *http://www.greenroofs.com*

The large lot sizes of these suburban developments also affect stormwater quantity and quality. Often, houses are located some distance from the street, requiring a long driveway, which adds additional impervious surface. The larger lawn sizes also contribute greater amounts of fertilizers and pesticides. Some solutions to these problems include amending the zoning by-laws to permit smaller lots or shared, narrower, or pervious driveways.

Figure 14: Abington's Stop & Shop and Target retail stores.

Commercial areas are responsible for a great deal of impervious surface seen in our communities. At most times, these parking areas are utilized at a small fraction of their total capacity. Figure 13 shows a commercial area on Route 123 in Abington where two large retailers each have a separate parking lot, both of which are only partially utilized. Combined parking could greatly reduce the amount of impervious surface, and could be encouraged by enacting parking maximums in zoning by-laws.

These Low-Impact Design techniques have much in common with the Sustainable Development Principles promoted by the Commonwealth of Massachusetts[5]. Both have an emphasis on concentrating development, mixing uses, and using natural resources wisely, and LID protects land and ecosystems from the negative effects of polluted stormwater.

[5] *http://www.mass.gov/governor/docs/smart-growth/patrick-principles.pdf*

Next Steps

Communities that begin taking steps towards reducing and improving the quality of their stormwater will see benefits not only in water resource quality, but will also have a head start on the requirements of the Environmental Protection Agency's NPDES program. Prior to the issuance of the new Phase II permit, communities may wish to examine how well they are in compliance with the new regulations. The EPA has provided a Compliance Assistance Guide (http://www.epa.gov/npdes/pubs/comguide.pdf) to walk communities through the process of adhering to the six minimum control measures.

Communities may also consider undertaking a Comprehensive Code Review, an examination of existing zoning by-laws and building regulations, to determine which comply well with the new regulations, and which could be amended. This is particularly important as it allows communities to ensure that future development does not worsen the situation, making compliance even more difficult. Zoning by-laws that concern impervious surface are a good place to start the review, as changes here can potentially have the most effect on the amount of stormwater runoff generated.

Low-Impact Design measures can also be required, as the Town of Plymouth has already done. The town makes its *Guide for the Design of Storm Drainage Facilities* available on its website at the following address: http://www.plymouth-ma.gov/public_Documents/PlymouthMA_Planning/GUIDEF~1.pdf

A comprehensive storm sewer system map is expected as part of the Illicit Discharge Detection and Elimination Program (IDDE). The EPA is especially concerned with mapping locations of outfalls. Old Colony Planning Council is available to assist in this data collection and mapping. OCPC currently has a Trimble GeoXT mobile GIS unit, with which it can do some of the in-the-field geolocation of outfalls and storm drains.

A changing climate may result in our region seeing an increase in annual rainfall, but even current amounts of stormwater have had a detrimental effect on the quality of our region's streams and ponds. The findings of this report will serve as a foundation for future OCPC efforts in bringing all our communities into compliance while preserving their character and livability for their residents.

Appendix: Drainage Field Sheet Example

Street Name/Route Number:

Waterway:

Town:

Date: / /

Staff:

CROSSING CHARACTERISTICS:

Culvert or Bridge

Height: __________

Width: __________

Crossing Length (width of roadway): __________

Date of Construction: __________

Roadway / Bridge Material: __________

Approximate Impervious Surface in Catchment Area: _________% (250 feet radius)

Land Use:

Flood Plain: N/A 100 500

Other Relevant Nearby Hydrologic Features:

Type of Flooding Observed in March 2010:

☐Waterway overflowing onto roadway

☐Ponding

☐Inadequate / Non-functioning Drainage

☐Not Studied

WATERWAY CHARACTERISTICS:

How wide is the stream?

How far below roadway level?

Is crossing obstructed?

What is the nature of the obstruction?

Is stream channelized?

Is sedimentation visible?

Obstacles to roadway drainage at location?

What type and size of drain?

Is there a seasonal difference in blockage?

Is the water visibly flowing or stagnant?

Other Notes: