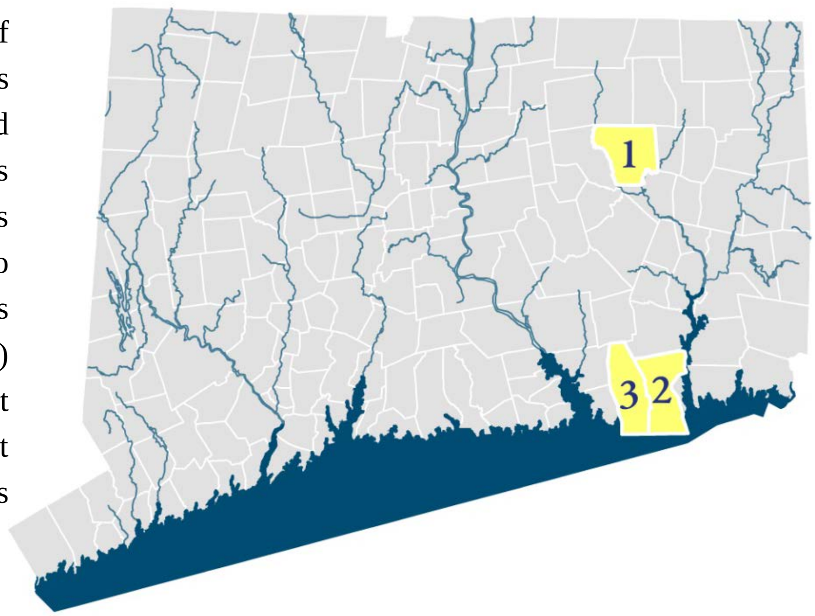
APPENDIX 5: CASE STUDIES

Examples of Action in CT Watersheds

The following pages contain a set of case studies of successful impervious cover and stormwater-related implementation efforts in different areas of Connecticut. Each of these summaries represents a different approach to implementing urban stormwater BMPs and Low Impact Development (LID) practices to reduce runoff and protect water quality. The map to the right indicates the locations of the case studies described below.



1. **Eagleville Brook, Mansfield, CT** – Developed in 2007, the Eagleville Brook TMDL was the first TMDL in the country based on impervious cover (IC) as a way to address streams impaired by complex urbanization-related impacts. The Eagleville Brook watershed is located in northeastern Connecticut and drains much of the University of Connecticut (UCONN) campus. Implementing this IC-based TMDL involves a collaborative effort among UCONN, CT DEEP, and the Town of Mansfield. Progress made to date indicates that the "IC-TMDL" approach may be a highly effective way to address impaired waterbodies afflicted with complex, unspecified water quality problems related to urbanization.

2. **Jordan Cove, Waterford, CT** - The Jordan Cove Urban Watershed Section 319 National Monitoring Program Project is located in Waterford, Connecticut along the coast of Long Island Sound. The study began in 1995, and was designed to determine water quantity and quality benefits using pollution prevention Best Management Practices (BMPs) in a residential subdivision. Monitoring was conducted over a 10 year period.

3. **Niantic River, East Lyme, and CT** - The Town of East Lyme has created an Outdoor Stormwater Classroom at the Hole-in-the-Wall parking lot located in downtown Niantic adjacent to the Long Island Sound. The parking lot serves as one of two main entrances to the Niantic Bay Boardwalk, Hole-in-the-Wall Beach, and local town beaches. The Outdoor Stormwater Classroom showcases the latest technologies and techniques utilized to treat and reduce stormwater runoff before discharging into Long Island Sound.

Case Study: Eagleville Brook, Mansfield, CT

A Collaboration Success Story

Eagleville Brook, located in northeastern Connecticut, is a tributary to Eagleville Pond, an impoundment of the Willimantic River. The 2.4 square mile Eagleville Brook watershed (Figure 1) drains a portion of the University of Connecticut campus in the Storrs section of Mansfield, Connecticut in Tolland County. The entire watershed is located in the Town of Mansfield and is a sub-regional basin in the Thames River watershed. Although much of the watershed is forested, and contains low-density residential development, the portion on the UCONN campus is heavily developed and contains large amounts of impervious cover such as rooftops, driveways, roads, sidewalks and parking lots (Dietz and Arnold, 2011).

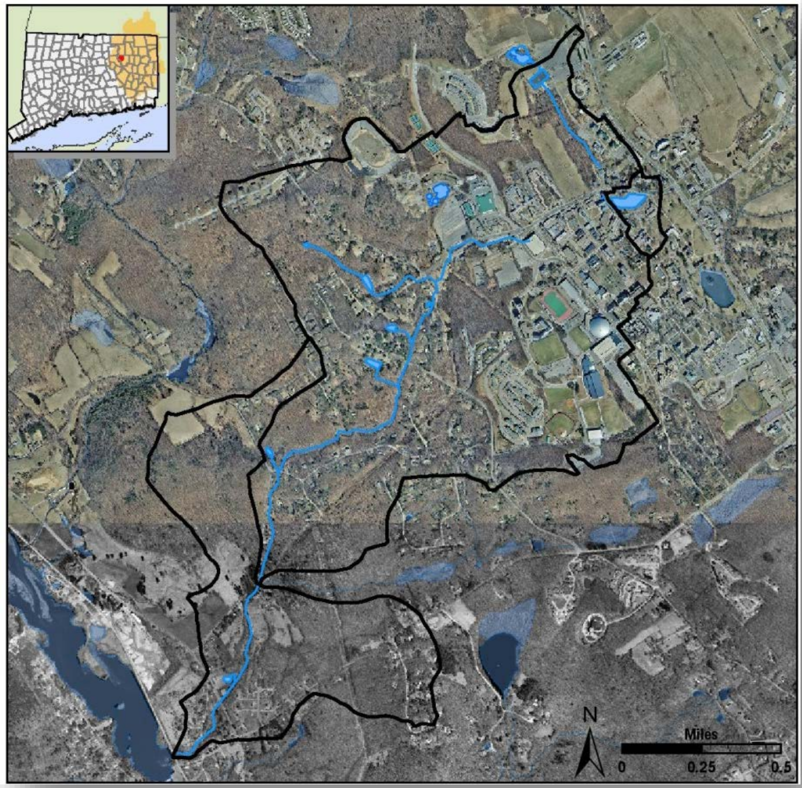


Figure 1: *The location of the Eagleville Brook watershed, outlined here in black, in Mansfield, CT. (CLEAR, 2012)*

In the upper Eagleville Brook watershed, there are two separate stream sections that are piped underground beneath the UCONN campus. One section is underground for approximately 600 feet and drains an intermittent section of the stream in the upper watershed. The section downstream of Swan Lake is underground for approximately 1,700 feet and daylights just downstream of a strip mall on the north side of North Eagleville Road. While underground, Eagleville Brook is combined with the stormwater drainage system for a portion of the UCONN campus (TRBP, 2009).

Background: The First Impervious Cover TMDL

The Connecticut Department of Energy and Environmental Protection (CT DEEP) conducted surveys of fish and macroinvertebrate communities in Eagleville Brook and determined that the brook is not meeting water quality standards for aquatic life support (CT DEEP, 2004). Section 303(d) of the Federal Clean Water Act require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies, commonly referred to as the "303(d) list". The Clean Water Act requires that all

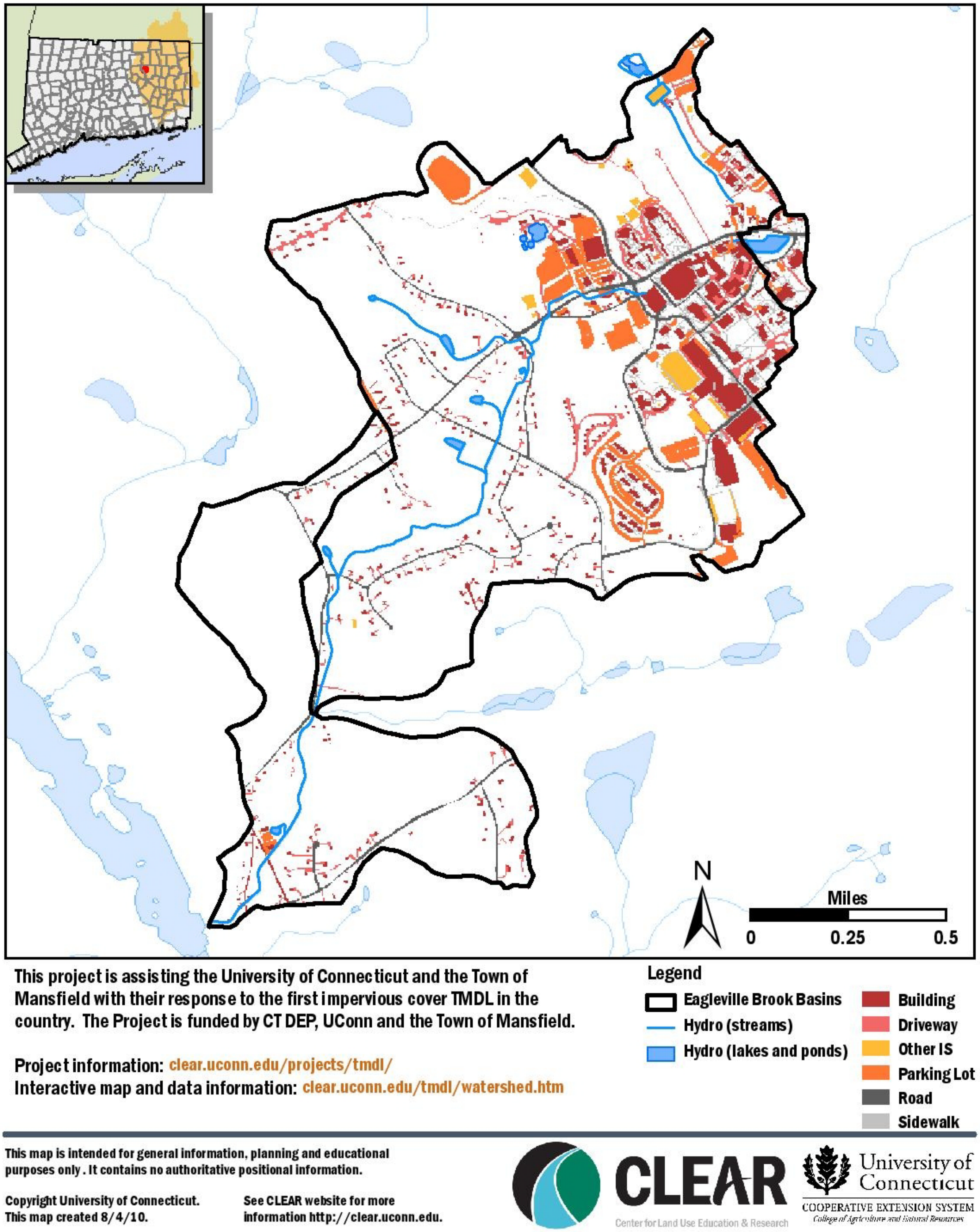


Figure 2: *Map of impervious surfaces in the Eagleville Brook watershed. The majority of the impervious cover is located in the upper watershed, within the UCONN campus. (CLEAR, 2012)*

303(d)-listed waters undergo a TMDL assessment that describes the impairments and establishes a target to guide the measures needed to restore water quality.

Although the Eagleville Brook impairment was identified, the cause was unknown. As part of the TMDL development process, DEEP conducted a Stressor Identification (SI) analysis to determine the most probable cause. It was determined that the most probable cause of the impairment was a complex array of pollutants transported by stormwater (Dietz and Arnold, 2011). The likely cause of the high quantity and low quality of this stormwater is the large amount of impervious cover (IC) in the watershed. Studies in small Connecticut watersheds indicate that as little as 11 percent impervious surface has the potential to affect the speed, the timing, and the quality of runoff to a stream (Dietz and Arnold, 2011). Parts of the Eagleville Brook watershed exceed 25% IC (Figure 2).

The Eagleville Brook TMDL was the first of its kind in the nation (Dietz and Arnold, 2011). Rather than identifying reductions in specific pollutants, the Eagleville Brook TMDL establishes a target percentage of IC for the watershed. Although IC is not the direct factor causing the impairment, it is a good indirect, or surrogate, measure because of the relationship between impervious surfaces and stormwater-related water quality problems. As stated in the final TMDL report, the goal of the TMDL is to reduce the effects of stormwater on aquatic life in Eagleville Brook (EPA, 2009). To develop the IC TMDL for Eagleville Brook, DEEP worked with key stakeholders, including UCONN's Center for Land Use Education and Research (CLEAR).

Actions: Collaborative Response to the TMDL

The Eagleville Brook TMDL was approved by EPA in 2007. A project partnership was formed to respond to the TMDL, led by the UCONN Center for Land Use Education and Research (CLEAR), in partnership with CT DEEP and the Town of Mansfield. All three partners provided funding and staff support for the project and for TMDL implementation.

Key elements of the TMDL response include: (1) geospatial data gathering and mapping; (2) field work to further refine the mapped information and to identify stormwater retrofit opportunities; and (3) educational and technical assistance to the Town of Mansfield, as well as more general educational efforts intended to help other communities navigate the IC TMDL process. The TMDL response is documented in the Eagleville Brook Watershed Based Plan (Dietz and Arnold, 2011). The Plan can be found online at: http://clear.uconn.edu/projects/tmdl/library/papers/EaglevilleBrookWMP-06-01-11.pdf.

The emphasis of the Plan is to reduce the amount and impact of directly connected IC, replacing it where practical, disconnecting it from the manmade Eagleville drainage network, and treating it where necessary (Dietz and Arnold, 2011). The project team assessed potential stormwater retrofit opportunities at 51 project sites in the Eagleville Brook watershed. Sites were primarily located on the UCONN campus, where most of the watershed's IC is found. The project team reviewed the 51 sites, accounting for factors such as feasibility, and educational or demonstration potential. The result was a "Top Ten" list of priority retrofits with preliminary design conceptual drawings for each site.

The Town of Mansfield's portion of the watershed is largely rural-residential, and represents only a small amount of the total IC (see Figure 2). For this section of the watershed, the focus is on future development rather than retrofits, emphasizing proactive Low Impact Development (LID) approaches and changes to road standards and maintenance (Arnold et al., 2010).

Progress is measured using a three-tiered set of criteria directly corresponding to the management goals:

- ***First tier:*** The amount of total, connected and disconnected impervious cover will be tracked. This will occur as projects (both new and retrofit) occur.
- ***Second tier:*** The hydrology of Eagleville Brook will be monitored at the weir (described in a previous section). This will allow the cumulative hydrologic impact of TMDL actions to be assessed.
- ***Third tier:*** CT DEEP will continue conducting stream macroinvertebrate and fish sampling at sample locations along Eagleville Brook. The biotic indices scores will allow assessment of the ultimate impact of the TMDL program on the health of the stream.

Outcomes: TMDL Implementation

Implementation of LID practices has been underway for several years on the UCONN campus. Table 1 lists the types and locations of practices that have been installed to date. Figure 3 shows LID practices utilized at the West Classroom Building, completed in 2011.

Table 1: *Low impact development practices installed at UCONN, 2004-2011. (CLEAR, 2012)*

Implementation Projects on UCONN Campus		
Location	**Year**	**Description**
Towers Dorms	2004, 2009	biorentention area, pervious pavement
Northwoods	2010	pervious pavement, biorention areas, rain gardens
Burton Shenkman	2006	biorentention area/biorentention swale, bioretention/wet detention basin, GrassPave (grid paver)
Lakeside Apartments	2005	EcoStone pervious interlocking concrete pavers
Gant Green Roof	2009	GreenGrid modules
West Classroom Building	2011	green roof, permeable interlocking concrete pavers, bioretention swale

***Figure 3:** Low impact development practices installed in 2011 at UCONN's new West Classroom Building: top left – bioretention swale in summer, top right – bioretention swale in fall, bottom left – green roof, bottom right – porous pavers. (CLEAR, 2012)*

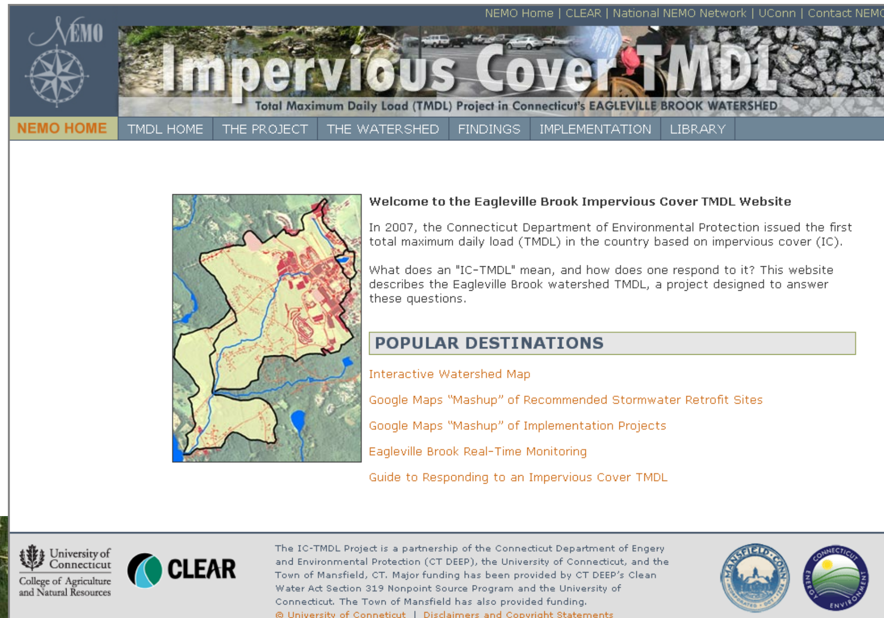
In addition to DEEP's continuing fish and macroinvertebrate sampling program in Eagleville Brook, a research weir, located just south of the main part of campus, has been renovated and daily volume measurements are being made. Although it is too soon to measure the water quality benefits from these implementation efforts, additional benefits from the TMDL process include the following (EPA, 2009):

- **Increased stakeholder awareness, education and involvement.** Stakeholders participating in the TMDL development process gained a better understanding of the connection between pollutant loads from impervious surfaces, the effects of stormwater volume and velocity from impervious surfaces, and changes to aquatic habitat and diversity. The process also fostered local involvement.
- **Support for innovative stormwater management techniques.** The Eagleville Brook TMDL has led to the consideration and piloting of innovative stormwater management techniques that fall under the umbrella of low-impact design.
- **Increased access to funding.** Clean Water Act Section 319 grant funding was utilized to create the Watershed-Based Plan for Eagleville Brook. Additional financial support has been provided by CLEAR, DEEP and the Town of Mansfield.

Future Steps:

With the Watershed-Based Plan for Eagleville Brook as the overall guide, the project team is working with the Mansfield Planning & Zoning Office to incorporate LID into the design and approval process for subdivisions and roads. In addition to continuing to work toward implementing the "Top Ten" list of priority retrofits on the UCONN campus, the project team is working with the UCONN Offices of Environmental Policy and University Planning to assist them in codifying their commitment to LID within the development design and approval process on campus (CLEAR, 2012).

The project website (Figure 4) serves as the repository for all project information, including educational materials; Google Earth-based displays of retrofit sites and associated technical documents, photos and other information; and real-time monitoring data. The content will continue to be populated as the project proceeds (CLEAR, 2012).



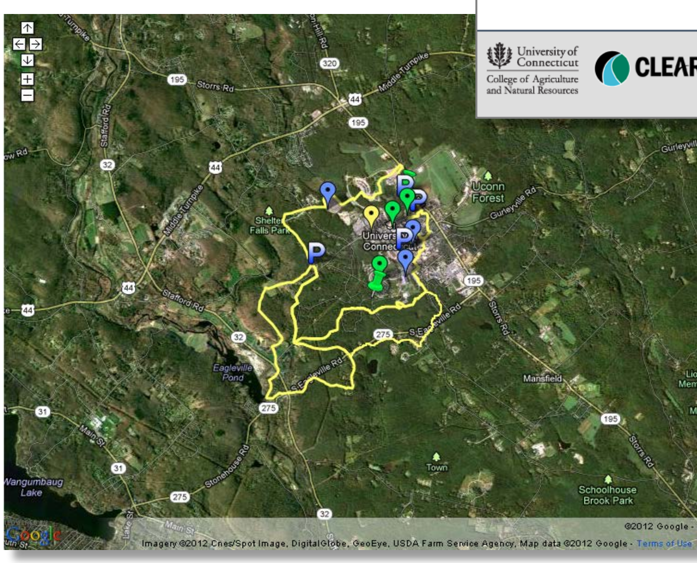


Figure 4: Top, right - Information about the Eagleville Brook TMDL project is detailed on the project's website. Bottom, left - The "mashup" is a map that shows the location of each retrofit site using Google Maps. Users can click on a retrofit balloon to access links to related information for each site. (CLEAR, 2012)

Over time, DEEP will measure the aquatic diversity in Eagleville Brook to determine if implementation efforts are making progress toward restoring the brook's aquatic life designated uses. Although the ultimate measure of success is meeting the aquatic life designated uses, progress toward reducing impervious cover and mitigating impacts from stormwater runoff can also serve as an interim measure of TMDL implementation success (CLEAR, 2012).

More information is available at the Eagleville Brook TMDL project website:

http://clear.uconn.edu/projects/tmdl/index.htm

References:

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Case Study: Jordan Cove, Waterford, CT

A Residential LID Monitoring Project

Figure 1: *Aerial view of Jordan Cove in Waterford, CT. (Google Earth)*

Jordan Cove is a small estuary located in Waterford, Connecticut along the coast of Long Island Sound. The Cove, fed by Jordan Brook, has impaired water quality due to excess bacteria. Water quality sampling had indicated that Jordan Cove did not meet bacteriological standards for shellfish growing, and sediment sampling had revealed high concentrations (>20 ppm) of arsenic. Also, short-term monitoring of bottom waters had documented depressed levels of dissolved oxygen. Land use in the 4,846-acre Jordan Brook watershed is mostly forests and wetlands (74%) along with some urban (19%), and agricultural (7%) uses (Clausen, 2007).

Background:

In 2005, the Jordan Cove Urban Watershed Section 319 National Monitoring Program Project was designed to determine water quantity and quality benefits of using pollution prevention Low Impact Development (LID) and Best Management Practices (BMPs) in a residential subdivision. The Jordan Cove project was funded, in part through the Connecticut DEEP by the U.S. Environmental Protection Agency's Section 319 National Monitoring Program (NMP). The project is one of the 24 NMP projects nationwide that studied the effects of residential subdivision development on runoff quality and quantity, and of practices designed to mitigate those impacts. The objectives of the Section 319 NMP are: (1) To scientifically evaluate the effectiveness of watershed technologies designed to control nonpoint source pollution, and (2) To improve understanding of nonpoint source pollution. The NMP selected watersheds across the country to be monitored over a 6- to 10-year period to evaluate the effectiveness of urban stormwater best management practices in reducing runoff and protecting water quality (CT NEMO, 2012).

Actions:

Project Design

The project was located in a residential section of the Jordan Cove watershed. The project design was based on a paired watershed approach; one watershed served as a control and two watersheds were treatment watersheds. The project plan was to develop one area following traditional subdivision requirements and another area of housing using LID and BMPs. These two areas were the treatment watersheds. A third drainage area, which was developed in 1988, was used as a control (Clausen, 2007; CT NEMO, 2012).

Figure 2: *Control watershed subdivision showing monitoring location. (Clausen, 2007)*

Control Watershed: A drainage area developed in 1988, consisting of 43 lots on 14 acres, was used as a control (Figure 2). Stormwater runoff was monitored at the outflow of a stormwater pipe at the watershed outlet.

Traditional Watershed (Treatment): The traditional watershed was five acres in size and was developed with 17 residential lots (Figure 3). This watershed was developed using standard zoning and construction practices. It is accessed by a 24 foot wide asphalt road with typical curb and gutter stormwater conveyance system. Before construction this area had a few small parking spaces, but it was mostly open with grass cover.

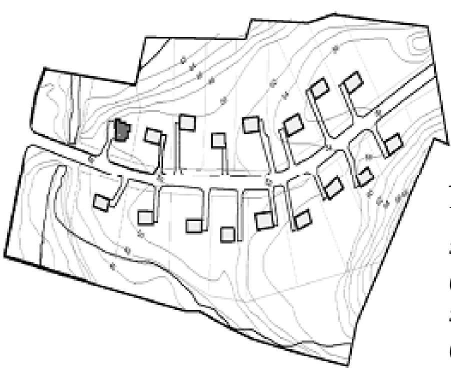

Figure 3: *Treatment watershed subdivision (traditional subdivision). (Clausen, 2007)*

LID Watershed (Treatment): The four acre LID watershed was developed with 12 lots (Figure 4). A cluster approach was used to aggregate homes closer together, leaving more open space in the watershed. Shared driveway entrances reduce imperviousness. Lawn sizes are reduced and low-mow and no-mow areas are designated to reduce fertilizer and maintenance impacts. The access road is narrower (20 ft.) than typically allowed by ordinance and is constructed of interlocking concrete pavers that allow infiltration. Before construction, this area was an old gravel pit, with a wetland in one section.

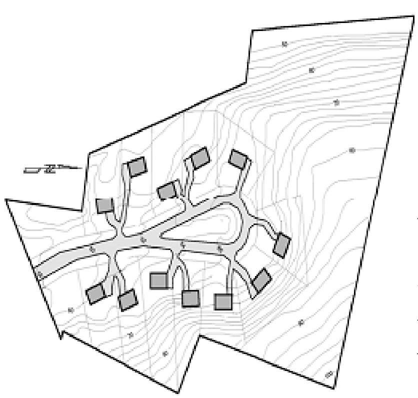

Figure 4: *Treatment watershed subdivision (Low Impact Development). (Clausen, 2007)*

Monitoring

The Jordan Cove project incorporated the paired watershed monitoring design for the three study areas (one control and two treatment watersheds). Precipitation, air temperature, and discharge were continuously monitored at the sites. Grab and storm-event samples were collected for biochemical oxygen demand (BOD) and common pollutants transported by stormwater including solids, nutrients, metals, fecal coliform. Monitoring of selected individual BMPs was also conducted (Clausen, 2007).

The project calibration period was approximately two years, during which time land use management in the watersheds remained unchanged. Once the calibration period was over, both the LID and traditional treatment watersheds were monitored during an 18-month construction phase and a long-term post implementation monitoring phase. During the construction phase, observations were made of earth-moving and construction activities in the traditional and LID watersheds. Residents in all three watersheds were also surveyed annually from 1994 to 2004 about yard maintenance behaviors such as mulching leaves, mowing lawns and fertilizer use (Bedan and Clausen, 2009).

Outcomes:

Table 1: *Construction and post-construction monitoring results in the treatment watersheds. (Bedan and Clausen, 2009; CT NEMO, 2012)*

What happened in the treatment watersheds during construction?
Traditional Subdivision Results: • As construction of an asphalt road, houses and driveways were installed, ***the stormwater volume per unit area running off the site increased significantly***. • The amount of key pollutants that entered local waterways also increased.
LID Subdivision Results: • Because practices were utilized to keep as much stormwater runoff on the site as possible, the stormwater runoff volume per unit area from the site during construction was ***29% less than what ran off the undeveloped site***. • Sediment and phosphorus increased, due to some large rain events that caused erosion in the grassed swales before they became established.
What happened in the treatment watersheds after construction?
Traditional Subdivision Results: • After the road surfaces, driveways and houses were installed, ***the stormwater volume per unit area running off the site increased by 16 times*** (compared to calibration period). • The amount of key pollutants that entered local waterways also increased.

LID Subdivision Results:

- The stormwater runoff volume per unit area after construction was ***42% less than at the undeveloped site.***
- Sediment and phosphorus export increased, due to some fertilization by homeowners in the grassed swales and possible grass clippings. However, the increase was much less than the increase in the traditional subdivision.

Conclusions:

The Jordan Cove paired watershed study demonstrated that implementing LID design significantly reduced storm flow and mass exports of several pollutants in stormwater compared with traditional development. LID can likely improve stormwater quantity and quality over traditional development methods in this region of the U.S (Bedan and Clausen, 2009).

Future Steps:

The results from the Jordan Cove study are being used to assist land use and natural resource managers by providing information on the relative effectiveness of LID and BMPs to control nonpoint source pollution (CT NEMO, 2012). The "Jordan Cove Urban Watershed Project" website provides planning, construction, post-construction and monitoring recommendations for future development projects. Some of the key planning recommendations include using a cluster design to reduce overall imperviousness, and increase open space; adopting LID-based regulations; and disconnecting stormwater (CT NEMO, 2012).

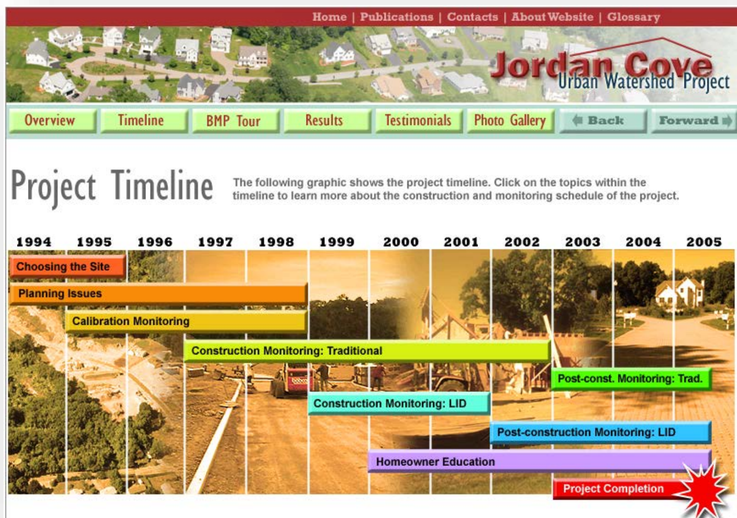

Figure 5: *Project timesline on the "Jordan Cove Urban Watershed Project" website.*

The website also provides recommendations for further study, including more intensive monitoring of groundwater and soil (to better understand the fate and transport of pollutants) and studying social indicators of behavior (to better understand the role of humans in a watershed) (CT NEMO, 2012).

More information is available at the Jordan Cove project website:

http://jordancove.uconn.edu/jordan_cove/about.html

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Case Study: Niantic River, East Lyme, CT

Outdoor Stormwater Classroom Project

The Niantic River is an estuary located along Long Island Sound in southwest Connecticut. The watershed covers 31 square miles, or approximately 20,000 acres, and includes parts of the four towns of East Lyme, Waterford, Salem, and Montville.

Much of the western side of the Niantic River watershed falls within the Town of East Lyme. In East Lyme, the area known as Oswegatchie Hills consists of over 700 acres of valuable recreational potential and diverse wildlife. It is also one of the last large stretches of undeveloped waterfront land in Connecticut (ECCD, 2009).

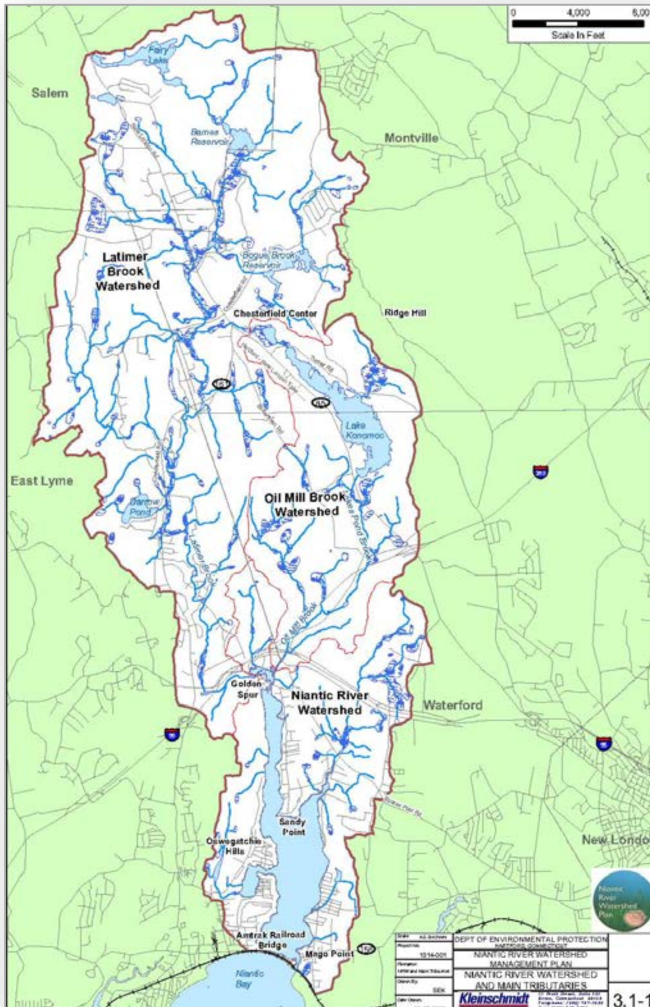

Figure 1: *The Niantic River Watershed. (NRW, 2010)*

Background:

The Niantic River does not meet state water quality standards because of high levels of indicator bacteria and observed degradation of aquatic life. Symptoms of this condition include, algal blooms, seasonal variations in eelgrass populations, loss of scallop populations and changes to the fish communities. An excess of nitrogen and bacteria, which flow to the river in stormwater, are the two greatest water quality concerns for the river. Bacteria and nitrogen enter the Niantic River from several sources, including marine vessels, inadequately functioning septic systems and stormwater runoff. It is estimated that polluted runoff, or nonpoint source pollution, accounts for approximately half of the nitrogen inputs into the Niantic River (CT DEEP, 2006). Nonpoint source pollution is the greatest threat to the water quality and ecological health of the Niantic River (NRW, 2010).

In 2006, a Niantic River Watershed Protection Plan was completed to help the watershed communities improve water quality throughout the watershed, eliminate shellfish bed closures, support fish and wildlife habitat and provide safe and healthy recreational areas. The Plan aims to better understand the current and potential risk of non-point source pollution in the watershed, and to determine what measures should be taken to decrease non-point source pollution to protect the Niantic River and its tributaries. The Plan encourages and supports municipal approaches to land-use planning, development reviews, and site inspections that protect watershed resources. By and large, land use planning and regulation, including the management of runoff (i.e. stormwater), lies with the watershed municipalities (ECCD, 2009).

Actions: Stormwater Quality Improvements & Education in East Lyme, CT

One of the key goals of the Niantic River Watershed Protection Plan is to develop and implement a comprehensive education and outreach program addressing water quality and watershed management issues (CT DEEP, 2006). To this end, the Town of East Lyme created an Outdoor Stormwater Classroom at the Hole-in-the-Wall parking lot located in downtown Niantic adjacent to the Long Island Sound. The parking lot serves as one of two main entrances to the Niantic Bay Boardwalk, Hole-in-the-Wall Beach, and local town beaches. The 1.1 mile Niantic Bay Boardwalk is one of the largest continuous stretches of public access to the shoreline in Connecticut. The Outdoor Stormwater Classroom showcases the latest technologies and techniques utilized to treat and reduce stormwater runoff into Long Island Sound. In addition to treating 23 acres of stormwater, the goal of the Outdoor Stormwater Classroom is to educate all people about the importance of keeping stormwater clean.

Figure 2: *The Hole-in-the Wall Outdoor Classroom. (Town of Lyme)*

Funding and Partners

Project partners include the East Lyme/Salem School system and Three Rivers Community College. Project concept, design and construction management was directed by the East Lyme Engineering Department.

The Outdoor Stormwater Classroom project was funded, in part, by the CT Small Town Economic Assistance Program (STEAP). Funding for the real-time weather and stormwater monitoring portion of this project was provided, in part, by the National Fish and Wildlife Foundation (NFWF). The NFWF $35,000.00 grant was awarded in 2006 and was matched by $606,384 in nonfederal contributions leveraging a total of $641,384. Funding for a Solar PV (Photovoltaic) Monitoring System was provided by the CCEF (CT Clean Energy Fund). (Town of Lyme, 2012)

Project Details

The Outdoor Stormwater Classroom project includes a 99-space pervious parking lot, grass filter strips, catch basins, a rain garden and dry well to reduce and treat stormwater runoff and conduct real-time monitoring of pollutants currently flowing from 22-acres into Long Island Sound.

Ten different types of pervious parking lots were installed along with educational signs to inform the public. The parking lot includes a number of pervious pavements with varying components (e.g., crushed stone, rubber tires, recycled plastic), detention basins, a rain garden, a tree box, and a stormwater monitoring system (Figures 3, 4 and 5).

The classroom contains educational signs posted throughout the parking lot. These signs demonstrate many of the latest technologies and techniques utilized to treat and reduce stormwater runoff before discharging into Long Island Sound.

Figure 3: *Examples of the different types of pervious parking lots installed at the Hole-in-the Wall Outdoor Classroom. (NFWF, 2009b)*

Figure 4: *The Hole-in-the Wall Outdoor Classroom. (Town of Lyme)*

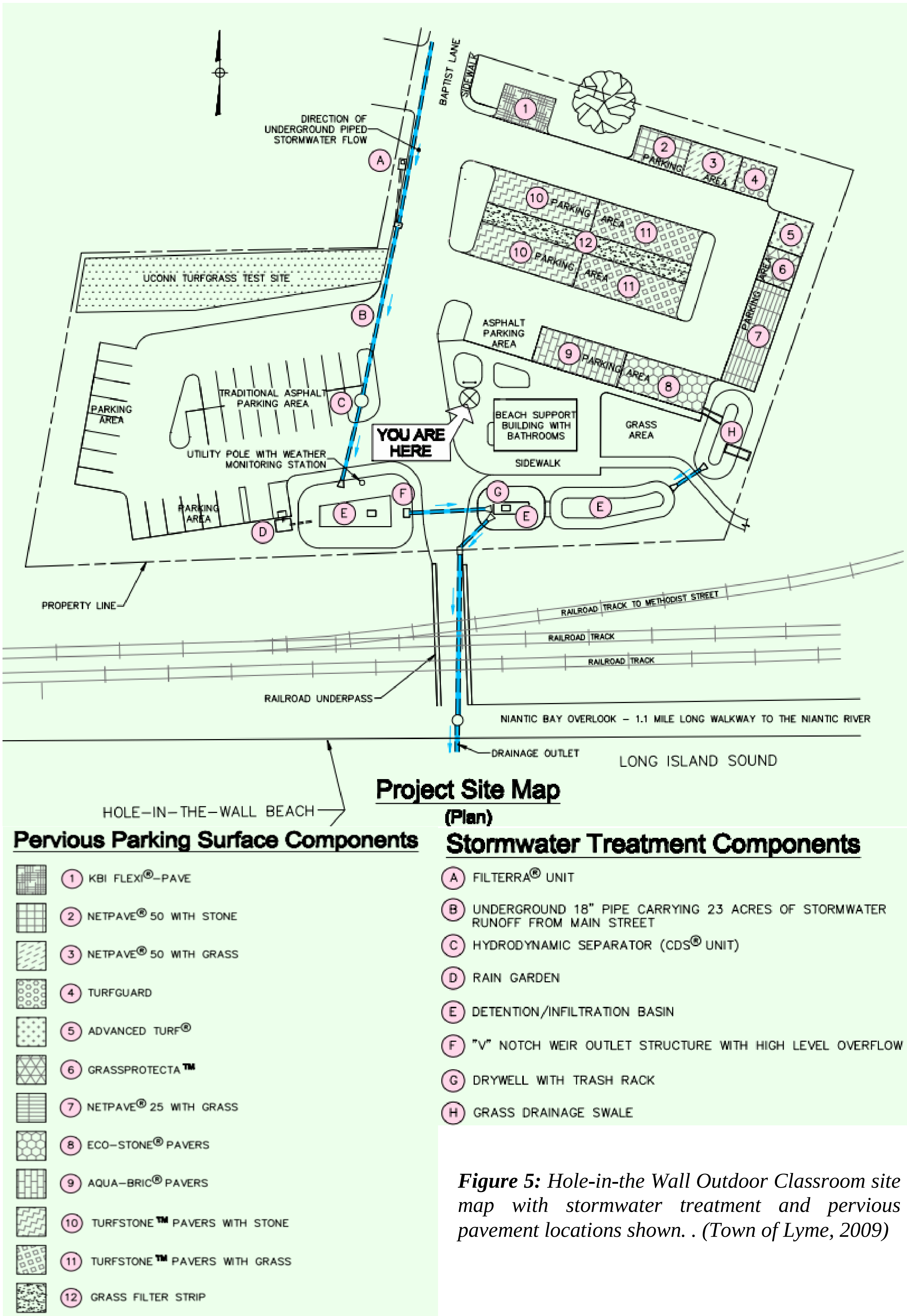

Figure 5: *Hole-in-the Wall Outdoor Classroom site map with stormwater treatment and pervious pavement locations shown. . (Town of Lyme, 2009)*

Outcomes:

In addition to treating 23 acres of stormwater, the goal of the outdoor stormwater classroom is to educate people about the importance of keeping stormwater clean. The Town gives guided educational tours and presentations of the Outdoor Stormwater Classroom project, Three Rivers College incorporates the project into its environmental classes and, as mentioned above, educational signs have been placed throughout the classroom to inform visitors (NFWF, 2009b).

As part of the Outdoor Stormwater Classroom project, the Town of East Lyme has also created a Solar PV (Photovoltaic) Monitoring System at a beach support building located within the Hole-in-the-Wall Parking Lot (Figure 5). This system monitors solar power generated to operate the building on a daily, weekly, monthly, yearly or custom basis. Monitoring this data allows anyone with access to the internet to study and determine the effectiveness of renewable energy (Town of Lyme, 2012). The link to this data can be found at: http://siteapp.fatspaniel.net/siteapp/simpleView.jsf?eid=660171.

Additionally, real time weather and stormwater data can be found on the project website. This data provides detailed insight into how well the stormwater treatment practices at the classroom are performing (NFWF, 2009a).

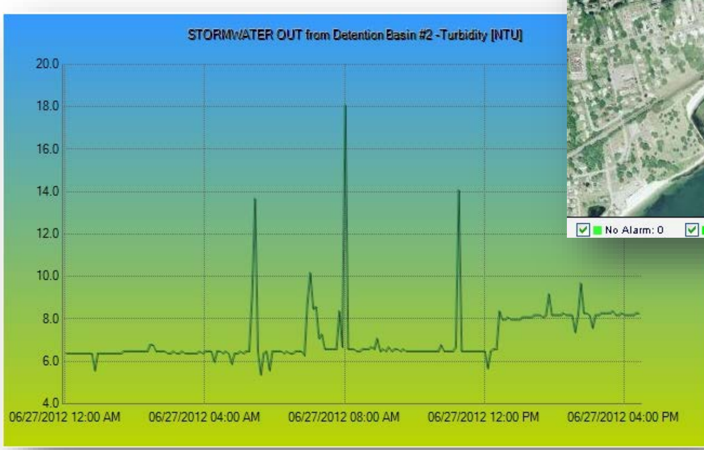

Figure 6: *Real-time weather and stormwater monitoring data can be viewed online at the Hole-in-the Wall Outdoor Classroom website. (Town of Lyme, 2012)*

For more information about the project, visit the Hole-in-the Wall Outdoor Classroom website:

http://www.eltownhall.com/hole-in-the-wall

For more information about the Niantic River, visit the Niantic River Watershed website:

http://www.nianticriverwatershed.org/

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