Eagleville Brook

Watershed Management Plan

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Executive Summary

This Watershed Based Plan comprises the response of the University of Connecticut and the Town of Mansfield, CT to the 2007 Eagleville Brook Total Maximum Daily Load (TMDL) analysis – the first of its kind in the country to be based not on a specific pollutant or pollutants, but on impervious cover.

The emphasis of the Plan is to reduce the amount and impact of *effective* (connected) impervious cover, replacing it where possible (i.e., porous parking lots, green roofs), disconnecting it from the manmade Eagleville drainage network (i.e., rain gardens, bioretention, green streets practices), and treating it where necessary (i.e., gravel wetlands and other water quality practices).

The Plan includes the results of a detailed watershed characterization and field surveys to identify low impact development (LID) retrofit opportunities, informed by the input of a wide group of stakeholders with strong representation from the three main project partners of CT DEP, UConn, and the Town. Watershed characterization is based on an analysis that began with the foundational research of CT DEP, expanded and enhanced that research using high resolution imagery and local data sets, and further refined the data via field work. Field surveys were conducted by teams from UConn CLEAR, the Center for Watershed Protection and the Horsley Witten group, with participation from CT DEP and UConn Office of Environmental Policy staff. The surveys identified 110 retrofit opportunities at 51 sites, almost exclusively on campus where the majority of the impervious cover is located. The information on each of these sites is included in the Appendices. Stakeholder input was received from stakeholder group meetings, and from frequent interaction with key offices and personnel from the three partners.

This Plan emphasizes LID practices for new development and retrofits for redevelopment in the upper (campus) portion of the watershed, and changes to land use regulations and practices in the lower (Town) portion of the watershed. Both of these initiatives are underway, and considerable progress has been made already (see Appendices). The consensus approach is a pragmatic one that emphasizes seizing opportunities as they arise during ongoing University and Town operations, rather than a strict timetable of particular projects at specific points in time. However, a framework has been created based on identified high priority projects; more detail on these projects is provided in concept papers and conceptual technical drawings, both of which are included in the Appendices. In addition, although it is somewhat outside the scope of this Plan, the expressed intent of both the University and the Town is to expand this work and incorporate identical practices and procedures for the areas of their jurisdictions outside the Eagleville watershed.

Since this is a precedent-setting TMDL, much thought has been given to methods of tracking progress. At present, the approach is a three-tiered system that focuses on:

1. Close tracking of the area of new and disconnected impervious cover.
2. Flow monitoring to ascertain whether changes in impervious cover will improve the hydrologic regime of the Brook.
3. Continued (CTDEP) monitoring of fish and macroinvertebrates, to track long-term trends in the health of the Brook.

Using the first tier as our primary short-term tracking system, and based on the updated watershed characterization and impervious cover disconnection estimates for both the Top Ten and all 110 projects, the TMDL 11% impervious cover goal seems achievable.

As with all WBPs, this Plan is to be considered a work in progress that is flexible and subject to change as the project continues and the three partners learn from their experience. To ensure coordination and oversight of implementation of the Plan, it is recommended that a Watershed Management Team coordinated by a part-time Team Leader be created.

Progress made to date indicates that the “IC-TMDL” approach may be a highly effective way to address listed waterbodies afflicted with complex, unspecified water quality problems related to urbanization.

Introduction

Eagleville Brook has been listed by the Connecticut Department of Environmental Protection (CT DEP) in the *2004 List of Connecticut Waterbodies Not Meeting Water Quality Standards* (CT DEP, 2004), due to exceedences of Connecticut's aquatic life criteria. Although this impairment was identified, the cause was unknown. It was determined that the most probable cause of the impairment was a complex array of pollutants transported by stormwater.

As a result of this listing, and in response to section 303(d) of the Federal Clean Water Act, CT DEP was required to develop a total maximum daily load (TMDL) for the watershed. The TMDL represents the maximum loading that a waterbody can receive without exceeding water quality criteria. The final TMDL for Eagleville Brook was completed in February 2007, and approved by the U.S. EPA shortly after. The Eagleville Brook TMDL was the first of its kind, in that it used impervious cover (IC) as a surrogate for the complex array of pollutants impairing aquatic life in the Brook.

In response to this precedent-setting TMDL, the UConn Center for Land Use Education and Research (CLEAR) led a two-year project to assist the University and the Town of Mansfield to respond. This Watershed Based Plan (WBP) constitutes that response, although implementation will be ongoing for the foreseeable future. All three partners -- CT DEP, UConn, and the Town – provided funding support for this project.

The goal of this Watershed Based Plan is to provide a single, cohesive document that can help guide future development at the UConn campus, help provide focus for retrofit opportunities, and facilitate communications between the Town of Mansfield and UConn in regards to stormwater and development issues. The EPA guidance document (US EPA, 2008) on WBP development was used as a reference for the creation of this watershed plan.

To facilitate practical use of the WBP, the authors have made a concerted effort to keep this document succinct. Additional information is contained in two major documents, the Eagleville Brook TMDL analysis itself, which describes the background studies and pollutant target calculations (CT DEP, 2007), and the Project Technical Report, prepared by the Center for Watershed Protection and the Horsley Witten Group, which details the technical results of field surveys and pollutant reduction estimates (CWP and HWG, 2010). Key information from these two foundational documents will be summarized and referred to in this WBP. Also, a narrative description of the project, covering the period up to the creation of this report, is contained in a paper published in Watershed Science Bulletin in October, 2010 (Arnold et al., 2010).

Eagleville Brook and its Watershed

Physical characteristics

Eagleville Brook is located in northeastern Connecticut, and has a 2.4 square mile drainage area (Figure 1). It is a tributary to an impoundment of the Willimantic River, Eagleville Pond, and is a sub-regional basin in the Thames River watershed. The entire watershed is located in the town of Mansfield. A portion of the heavily developed University of Connecticut main campus is located within the watershed (Figure 2). Although much of the watershed is forested with low-density residential housing, the portion on the UConn campus is essentially an urban area, with large amounts of impervious surfaces. A portion of Eagleville Brook is piped beneath the campus, similar to many urban streams.

Four subwatersheds of Eagleville Brook have been identified, and two segments of the Brook (Eagleville Brook_01 and Eagleville Brook_02) have been found to be impaired (CT DEP, 2004). The surface water classification for both segments of the Brook is B/A. The B/A classification means that Eagleville Brook is not meeting the goal of Class A Water Quality Criteria and attainment of Class A designated uses.

Sources of pollution that need to be controlled

The most probable cause of the aquatic life impairment is “a complex array of pollutants transported by stormwater,” as identified in the TMDL. The likely cause of the high quantity and low quality of this stormwater is the large amount of impervious cover (IC) in the watershed. In this innovative TMDL, IC was used as a surrogate measure of the complex array of pollutants. Justification for the use of this surrogate can be found in detail in the TMDL analysis document (CT DEP, 2007). An analysis of stream health (using several macroinvertebrate indicators) and impervious coverage was performed by CT DEP for 125 streams in Connecticut (Bellucci, 2007; CT DEP, Appendix 2, 2007). Findings from this analysis indicated that no streams met Connecticut’s aquatic life criteria when there was more than 12% IC in the watershed. Although there was substantial variation in stream health in watersheds with less than 12% IC, the 12% level was identified as an appropriate threshold for aquatic life impairments.

Load reductions needed

CT DEP applied a margin of safety (MOS) of 1% for the TMDL target; therefore the overall IC target for the watershed as identified in the TMDL document is 11% IC, or 154.2 acres. After updating CT DEP modeling with high resolution imagery, the watershed IC was determined to be 16.9% (236.2 acres), 51.0 acres of which was determined to be disconnected.

The “effective” IC in the watershed is therefore (236.2 – 51.0) = 185.2 acres, making the load reduction goal (185.2 – 154.2) = **31.0 acres of IC** (Table 1).

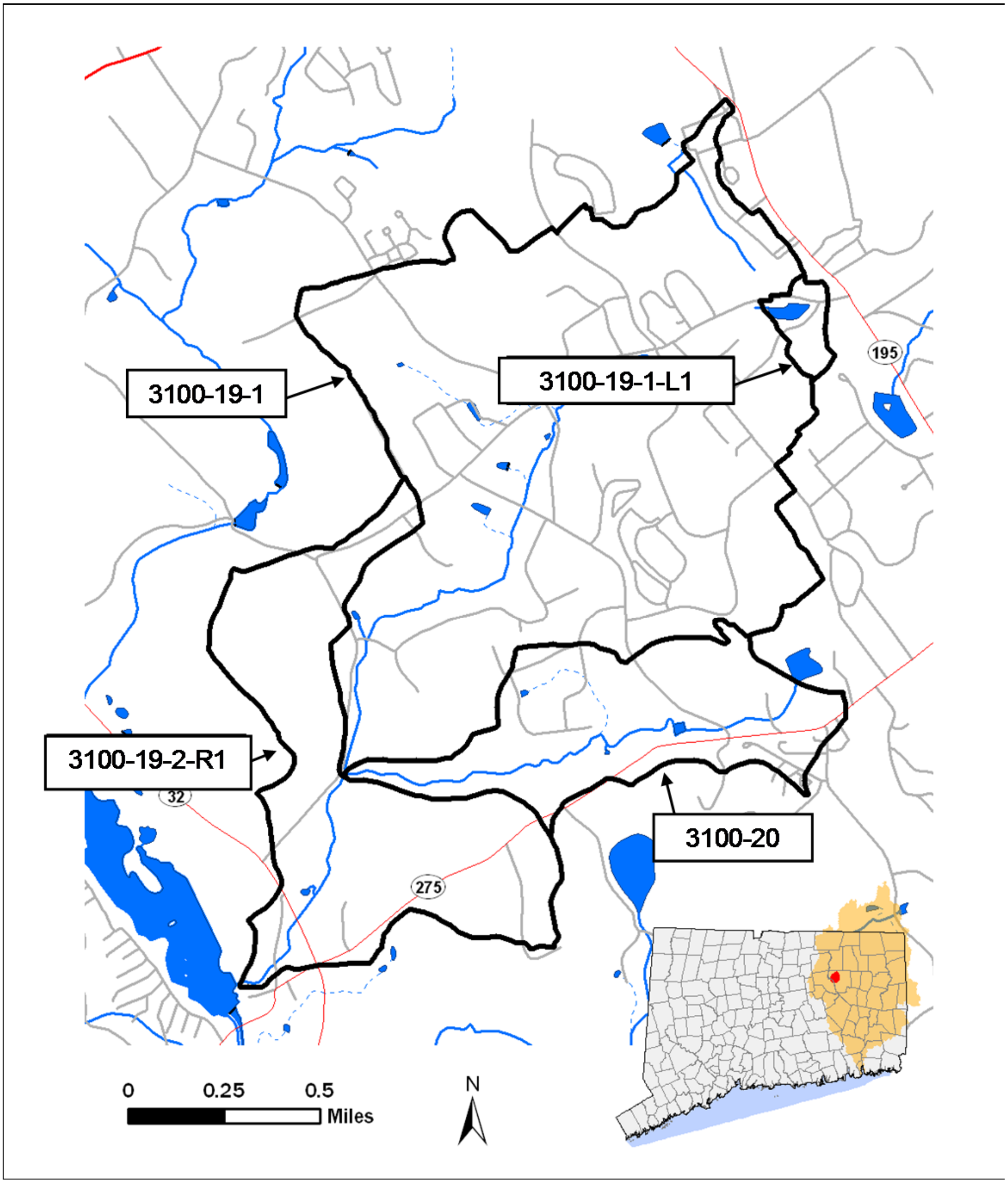

Figure 1. Eagleville Brook watershed and sub-basins. Inset shows position of watershed (red) within the Thames River basin (orange).

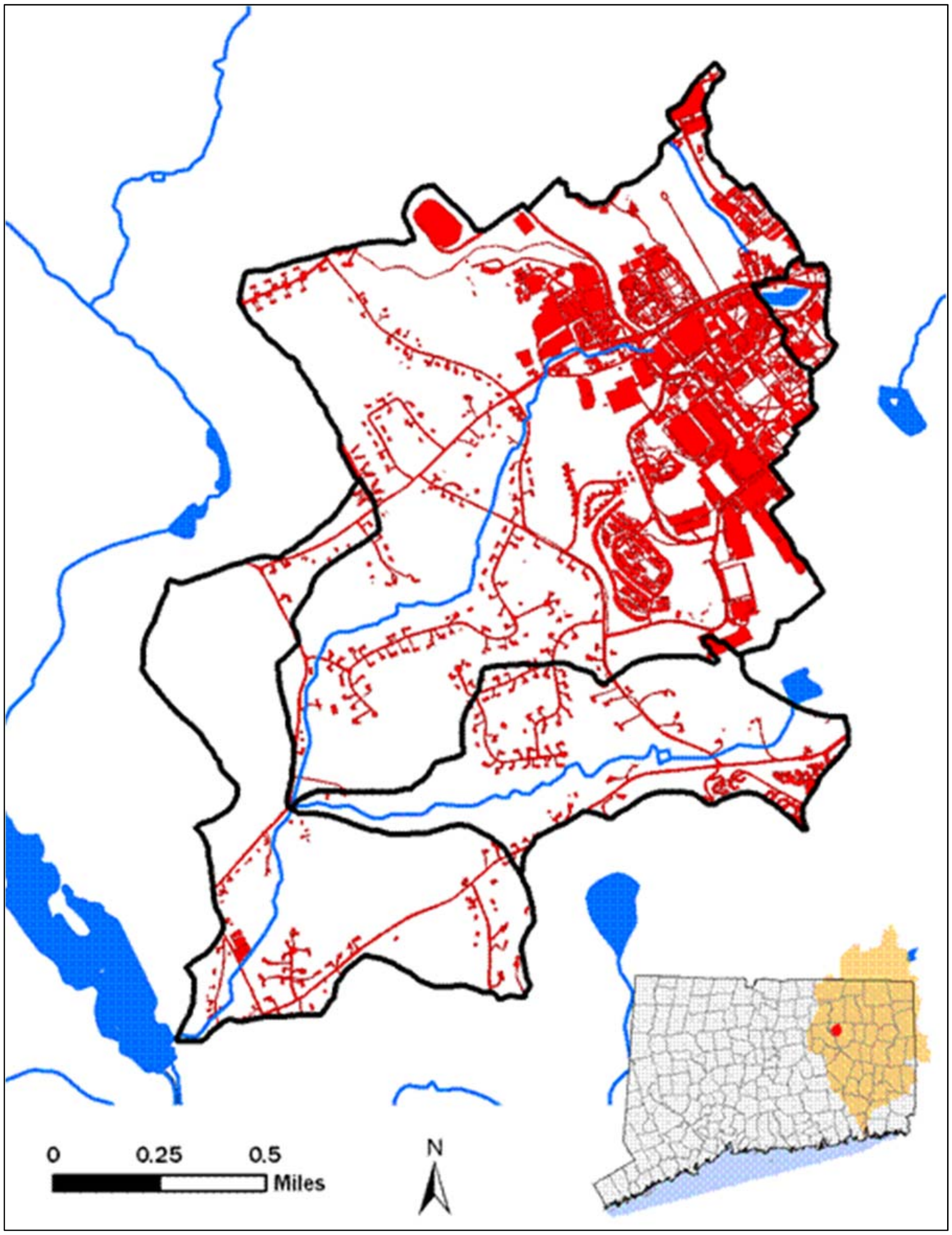

Figure 2. Eagleville Brook watershed, with impervious cover in red. Inset shows position of watershed (red) within the Thames River basin (orange).

Table 1. Characteristics of sub-basins in Eagleville Brook Watershed.

Sub-basin number	Basin acreage	TMDL ESTIMATE IC Acreage	TMDL ESTIMATE % IC	FIELD VERIFIED IC Acreage	FIELD VERIFIED % IC
3100-19-1	869.0	121.7	14.0%	195.2	22.5%
3100-19-1-L1	18.3	5.0	27.0%	7.1	38.8%
3100-19-2-R1	305.3	15.3	5.0%	14.9	4.9%
3100-20	208.9			19.0	9.1%
Total basin	1401.6	141.9	10.1%	236.2	**16.9%**

Total basin area (ac)	1401.6
Total IC (ac)	236.2
Disconnected IC (ac)	51.0
Corrected IC (%)	13.2%
Effective IC (ac)	**185.2**
IC target (ac)	154.2
Disconnection needed (ac)	**31.0**

It should be noted that the TMDL is for *total* impervious cover. The statewide research that the target IC was based on also used total impervious cover as the variable to compare with stream health. This is the only practicable approach when looking at landscapes at this scale. However, at the small scale of Eagleville Brook, the partners agreed that the TMDL response needed to focus on reducing *effective* impervious cover, the amount of IC that is directly connected to the stormwater system. This distinction is important; a watershed may have substantial IC, but if runoff from the surfaces is directed to pervious areas instead of into a piped stormwater system, the impact on local water bodies may be very small. Conversely, a turf area with highly compacted soils could generate runoff like an impervious surface. This distinction is likely part of the explanation for the variability in stream health noted at watershed IC percentages below 12% (CT DEP, Appendix 2, Figure 4, 2007).

Management goals

Reduction in effective IC may be accomplished by removing IC, directly disconnecting impervious areas from the stormwater system, or by providing equivalent IC reductions in the watershed. It should be noted that this is the target for the entire watershed. To be most effective, reductions in effective IC will likely need to be targeted at the more heavily developed UConn campus.

As shown in Table 1 and noted above, the project team first updated and improved the TMDL analysis estimates of IC, by hand-digitizing IC from higher resolution and more recent satellite imagery (from 2008). In the summer of 2009, this analysis was followed by an extensive field survey conducted by CLEAR faculty and experts from the Center for Watershed Protection (CWP) and Horsley Witten Group (HWG). Staff from the UConn Office of Environmental Policy and CT DEP also participated in the field work.

A total of 110 potential projects at 51 sites within the watershed were identified where IC disconnections could occur. Disconnected IC area and estimates of runoff volume reduction for each of these areas were calculated (CWP & HWG, 2010). Pollutant load reductions (phosphorus, nitrogen and suspended solids) were also calculated for each project based on national average removal rates. Because load reductions were based on national averages for various BMPs, actual load reductions may be more or less than the assumed value.[1] The TMDL analysis states that the goal of the TMDL is to have the Eagleville Brook watershed act ***as if*** the watershed were no more than 11% impervious cover. Thus, the watershed management goals for the Eagleville Brook watershed go beyond strict accounting of IC and include the following:

1. Achieve a healthy stream ecosystem, as indicated by CT DEP biotic indices.
2. Restore more natural hydrologic function to Eagleville Brook.
3. Reduce the effective impervious cover in the watershed
   a. Reduce overall IC where possible
   b. Disconnect IC where possible
   c. Mitigate impacts of IC where possible
4. Create implementation and planning procedures to ensure the Town of Mansfield and UConn continue to pursue goals 1-3.
   a. Implement a LID checklist for new projects in the Town of Mansfield and on the UConn campus
   b. Establish a Watershed Management Team to track implementation of Watershed Management Plan

[1] Since the "pollutant" of this TMDL is impervious cover, detailed measurements of total and effective IC take the place of pre-implementation monitoring in a more conventional TMDL. Presumably, this is one practical and financial benefit of the IC-TMDL approach. However, with regard to post-implementation monitoring of this particular project, the project team felt that in addition to tracking IC, hydrologic and, if possible, water quality parameters should be monitored to investigate the effectiveness of the IC-TMDL approach. In the future this may not be needed and represents an additional benefit to this approach.

Management measures to achieve goals

Overall Management

The establishment of the Watershed Management Team as recommended in Objective 4a will have the entire watershed as its scope. The directives of the Team will be the following:

1. Track implementation of the Management Plan
    a. Obtain relevant information on IC changes as a result of new projects or developments in the watershed
    b. Disseminate this and other relevant updated information to the interested parties via the project website
2. Organize four meetings per year to discuss progress and identify areas where support is needed
3. Coordinate efforts to obtain additional funding to reduce IC in the watershed
4. Develop annual work plans based on available funding

The Team will have representation from the three project partners of UConn, the Town of Mansfield, and CT DEP. UConn members may be from the following managerial departments (Architectural, Engineering & Building Services, Office of Environmental Policy, Facilities Operations, Residential Life, or others as appropriate) and the following academic departments (Extension, Civil and Environmental Engineering, Natural Resources and the Environment, or others as appropriate). Town of Mansfield members may be paid Town employees, members of Commissions, local business owners, or residents.

It is recommended that a part-time (0.25 FTE) Team Leader position be funded to oversee and manage the Watershed Management Team. Funding for this position could come from external sources, or from UConn. The Team Leader would be responsible for ensuring progress toward, and documentation of, the management goals as outlined above, in consultation with the Management Team.

Implementation Framework

Since the Eagleville Brook watershed is quite diverse with regard to land cover, management measures may be different for each sub-basin. Therefore, specific recommendations for sub-basins are proposed, in concert with implementation objectives identified in the TMDL:

Stream reach CT 3100-19_01

The watershed of stream reach CT 3100-19_01 contains large tracts of undeveloped forest and fields, and some low-density residential housing. This reach drains sub-basin 3100-19-2-R1. King's Brook (basin 3100-20) also drains to this reach, as does the upper reach of Eagleville Brook (CT 3100-19_02). Therefore, the management measure recommended in this sub-basin is anti-degradation. This sub-basin is not located on UConn property, so the Town of Mansfield would have primary responsibility for maintaining its function. This could be achieved through evaluating any new proposed development through the lens of this plan. Homeowner education regarding landscape management practices might also be beneficial to the Brook. However, the potential impact on water quality in Eagleville Brook would likely be fairly small due to the dominant impact from the UConn campus, which feeds into this segment from upstream.

The Center for Land Use Education and Research (CLEAR) is currently assisting the Town in reviewing its subdivision regulations and road design standards, to look for opportunities to encourage responsible growth using Low Impact Development (LID) techniques. The goal of LID is to preserve the predevelopment hydrology of a site, thereby reducing downstream impacts. Some LID tools that could be used include the following, as recommended in the Connecticut Stormwater Manual (CT DEP, 2004) and the LID manual (Prince George's County, 1999):

1. Include site planning early in the development process
2. Preserve natural hydrologic features where possible
3. Keep disturbance of soils and existing vegetation to a minimum
4. Use bioretention, rain gardens, grassed swales, water harvesting, and vegetated roofs where possible

One of the recommendations that CLEAR faculty have made to the Town of Mansfield is to require applicants submitting new projects to complete a checklist. This checklist contains various LID items that are suggested for residential developments. The structure of the checklist is such that a developer first is asked which LID components they will be using on a project. If LID cannot be used, the reason for this must be justified. After consulting with the technical project team, checklists from Attleboro, MA, Guilford, CT, and the new 2010 Rhode Island Stormwater Design and Installations Standards (RI DEM & CRMC, 2010) were reviewed; the CLEAR team created a composite of these examples for the consideration of Mansfield (Appendix A).

Stream reach CT 3100-19_02

This reach drains two sub-basins. Both sub-basins are highly developed, with 38.8% IC in the smaller watershed around Swan Lake[2] on the UConn campus (3100-19-1-L1), and 22.5% IC in basin 3100-19-1 (Figure 2, Table 1). The first implementation objective for basin 3100-19-1 is to preserve the integrity of the undisturbed portions of the watershed. For example, in the headwaters of the Brook, north of where it enters the

[2] Field research from this project as well as earlier research by Dr. Jack Clausen of UConn have shown that Swan Lake drains to the Fenton watershed under all conditions but very high flow, at which point it drains to both the Fenton and Eagleville. The size storm at which this occurs is not known. However, since this subbasin was included in the TMDL, we have included it in this WBP.

channel under the campus and west of the towers dorm complex, the area surrounding the Brook is in excellent condition, with a substantial wooded buffer on both sides. This condition should be maintained to preserve the existing function in this section of the Brook.

The next implementation objective for both sub-basins in this reach is to reduce the percentage of connected impervious cover, accomplished by improved stormwater management. Due to the high percentage of IC on the UConn campus, reduction of effective IC will need to be accomplished through retrofitting existing sites. This may involve physical removal of IC where it is not functional, such as in satellite parking areas that are in poor condition, or replacement of impervious areas with pervious alternatives. However, it will more often involve physical disconnection of IC, by techniques such as redirecting roof leader downspouts to pervious areas. Installing bioretention areas to capture runoff from parking lots and/or roads will also be a valid way to reduce effective IC.

The field survey performed in the summer of 2009 identified 110 retrofit opportunities at 51 sites around the portion of the UConn campus in the Eagleville Brook watershed (available at http://clear.uconn.edu/projects/tmdl/library.htm). A list of high priority projects was also developed, based on both technical and non-technical factors. (Appendix B). If the high priority projects were implemented on campus, the effective IC would be reduced by 30.5 acres, and 32 pounds of phosphorus, 207 pounds of nitrogen, and 6430 pounds of suspended solids would be prevented from reaching Eagleville Brook. The estimated cost to implement these high priority projects is $1,350,600 (CWP & HWG, 2010). Pollutant load reduction and cost estimates for the high priority projects can be found in Appendix B. In addition, two-page concept papers and 25% design drawings were developed for the high priority projects; these are contained in the Technical Report, and are posted on the project website.

These projects should be used as suggested techniques to reduce effective impervious cover in the watershed. Individual projects may require modifications to the preliminary plans as input is received throughout the design process, and as site conditions are determined. However, the area of IC treated for each of the projects should remain consistent with the area listed in the Technical Report. Additionally, as projects are in the detailed design phase, consideration should be given to how the proposed project fits in with the Campus Landscape Master Plan (Sasaki, 2010). A reasonable attempt should be made to align the goals of individual TMDL-related projects with this Plan.

It has been noted that many of the turf areas on the UConn campus are highly compacted, and therefore the infiltration capacity has been reduced such that these surfaces act more like an impervious surface. Renovation of soil structure in such locations would likely improve the infiltration capacity at the site, reducing the volume of stormwater that runs off. This approach could help reduce the effective impervious area of this highly developed portion of the watershed, and is recommended where feasible on campus.

It is recommended that the Architectural, Engineering & Building Services division at UConn require all new and renovation project proposals to include a checklist similar to the one used by the Town of Mansfield. Although LID practices are becoming more common on campus, and AEBS staff has been recommending the use of LID in new projects, a checklist will help to provide clear, consistent guidance to outside firms who want to perform work on the UConn campus. Discussions are underway with the Office of Environmental Policy and the Office of University Planning to implement such a checklist (see Appendix A). The Office of University Planning has initiated a larger review of processes and procedures that project applicants need to conform to, with the goals of streamlining the process for applicants, while ensuring compliance with regulations and protection of natural resources. The expectation is that the LID checklist will become a part of this revamped process.

The Eagleville Brook watershed bisects the University campus (Figure 2). Although this Plan is aimed at the area of campus that is in the Eagleville Brook watershed, it is recommended that the University strive to implement these management procedures for the entire campus. It should be noted that the adjacent watershed drains to the Fenton River, which supplies the drinking water reservoir for the City of Willimantic a short distance downstream.

Implementation schedule, milestones, and evaluation criteria

Several different entities will need to collaborate to implement this watershed management plan. Table 2 identifies action items and associated timelines, products, and evaluation criteria.

It is important to note that, despite the framework of the high priority projects, implementation on campus will take place not in a linear progression of projects but in an opportunistic fashion, as new development, redevelopment, and other initiatives (e.g., landscape plans) present opportunities to incorporate TMDL-related practices. This philosophy, by consensus of the project partners, is deemed to be most pragmatic and cost-effective, and thus most likely to yield results. In fact, significant implementation, including high priority projects, has already occurred or is underway, in advance of this WBP. See Appendix C for a summary of these projects.

Table 2. Action items, timelines, products/milestones, and evaluation criteria.

Action items	Lead entity	Timeline	Products	Evaluation criteria
Form Watershed Management Team, including Team Leader	CLEAR	1 year	4 meetings per year	Participation, recommendations from Team to Team Leader
Develop LID checklist for new projects	CLEAR/Town of Mansfield/UConn AEBS, OUP & OEP	1 year	LID checklist	Adoption of checklists by Town of Mansfield and UConn AEBS & OUP
Continue water quantity monitoring and increase water quality monitoring	UConn NRE department	1 year	Monitoring results	Correlation (or lack thereof) of TMDL implementation with water quantity and quality trends
Implement high priority stormwater retrofits on UConn campus	CLEAR/UConn AEBS, OUP & OEP	0-5 years	Completed projects	Documentation of successful project implementation
Implement other LID retrofit opportunities as they are identified	CLEAR/UConn AEBS, OUP & OEP	0-10 years	Completed projects	Documentation of successful project implementation
Construct new projects incorporating TMDL goals and LID practices	Town of Mansfield/CLEAR/UConn AEBS, OUP & OEP	0-10 years	Completed projects	Amount of total and effective IC added/subtracted from watershed

CLEAR=University of Connecticut Center for Land Use Education and Research
AEBS=Architectural Engineering and Building Services
OUP=Office of University Planning
OEP=Office of Environmental Policy

Monitoring

Measurements of new IC disconnections will be performed. Each incremental disconnection will be added to the area already disconnected, to measure progress towards the goal of 35.0 additional acres to be effectively disconnected. As noted in Table 2, new projects will also be evaluated for their effect on the total and effective IC totals for the watershed.

In addition to IC disconnections, benthic macroinvertibrates were identified as the primary metric to measure progress of meeting Aquatic Life Support in Eagleville Brook. Project partner CT DEP conducts these surveys, and intends to continue this work in Eagleville Brook.

A weir and datalogger have also been installed in Eagleville Brook just west of the main campus (Figure 3), in order to track water quantity in the Brook at this point. Data from the weir will provide background information on the hydrologic response of the campus watershed to precipitation events, and provides an additional metric to track as IC disconnections occur. This monitoring began in November 2009. Precipitation is also being measured on campus, (approximately 1200 feet away from the weir) as part of the green roof monitoring project. Daily precipitation and flow at the Eagleville Brook weir have been summarized (Figure 4), and these data are available upon request.

CLEAR faculty member Michael Dietz and UConn Professor John Clausen have recently obtained a small grant to purchase equipment to automatically post the real-time monitoring results to the World Wide Web. This website is currently operational, and can be accessed at http://clear.uconn.edu/projects/eagleville, or through the TMDL project website, located at http://clear.uconn.edu/projects/tmdl/.

CT DEP has performed some water quality measurements downstream of the weir. More detailed sampling for chlorides, metals, and phosphorus has been proposed by CLEAR for FY11 Section 319 funding support. An EPA approved Quality Assurance Project Plan (QAPP) will be required before this monitoring commences.

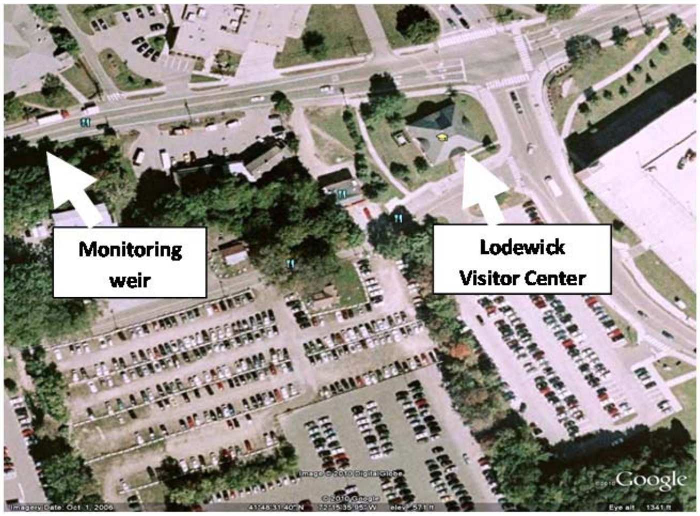

Figure 3. Location of monitoring weir.

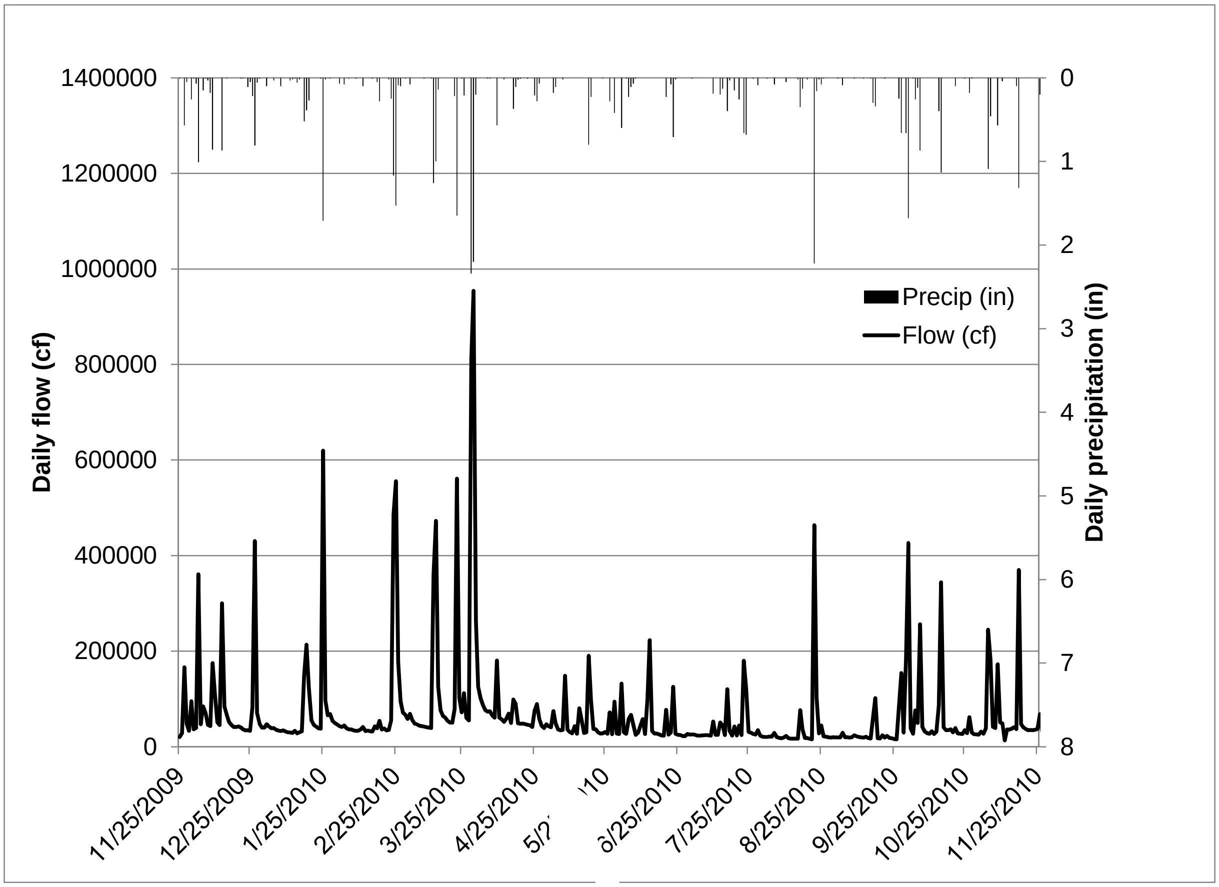

Figure 4. Daily flow and precipitation at Eagleville Brook monitoring site.

Measuring progress

Progress will be measured with 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: As noted, CT DEP will continue its stream macroinvertebrate sampling in the 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.

This Plan may also be revised to reflect updated monitoring data, or other circumstances that necessitate a change in focus to achieve the initial goals of the Plan.

Education/outreach

Several members of UConn Extension have been involved with the TMDL process since its inception. This representation from the CT Nonpoint Education for Municipal Officials (NEMO) and Center for Land Use Education and Research (CLEAR) teams brings many years of experience in providing education to a variety of audiences on similar topics. To date, contributions of the CLEAR/NEMO team include:

-Technical guidance on design and installation of practices

-Training for facilities and landscape staff on installation and maintenance of LID techniques

-Publicly available electronic media (website http://clear.uconn.edu/projects/tmdl/) with information on the progress of the project, documents, and interactive maps.

-Presentations on the project have been made at 6 regional or national conferences, and two papers or proceedings have been written to date.

- An informational brochure about the watershed and the TMDL has been created.

It is suggested that information about this project continue to be posted on the website, and that, as funding permits, CLEAR/NEMO staff be available to give talks on the project, both to interested towns in CT and at appropriate regional and national venues.

Additionally, it is suggested that an informational workshop about the watershed and the TMDL be developed. CLEAR faculty and the Town Planning Office are in discussion about the timing of such a workshop.

Technical and financial assistance needed

Cost estimates for 110 projects were calculated (CWP & HWG, 2010). Potential funding sources were not identified in the TMDL Analysis Report, however it is expected that funding for implementation will come from a mixture of internal UConn and Mansfield funding, in-kind donations of labor and/or materials, and externally obtained grants.

Maintenance costs have not yet been calculated. It is estimated that the bulk of maintenance costs will be contributed as in-kind labor/materials from University of Connecticut Facilities and Landscaping programs.

Given that this project is centered on the UConn campus, technical expertise is readily available. A variety of staff from the following departments have worked on this project to date: Architectural Engineering and Building Services (AEBS), Office of

Environmental Policy (OEP), Office of University Planning (OUP), Extension (CLEAR, NEMO), and the Natural Resources and the Environment department. Two outside organizations with extensive LID experience, the nonprofit Center for Watershed Protection, Inc., and Horsley-Witten Group, have also worked on various aspects of the project. Additional technical support has been provided by CT DEP staff. Also, through the implementation of the TMDL checklist, it is anticipated that contractors working on both new construction and renovation projects at UConn and in Mansfield will be required to supply technical expertise of their own.

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APPENDIX A. Proposed Guidance and LID checklists for UConn and Town of Mansfield

Guidance Document for Low Impact Development

Best Management Practices for UConn

June, 2011

In 2007, the Connecticut Department of Environmental Protection approved a Total Maximum Daily Load (TMDL) for the Eagleville Brook watershed in Mansfield, CT. Aquatic life impairments in the brook were the driving force behind development of this TMDL. Typically, a TMDL is written for a pollutant such as nitrogen, phosphorus, or bacteria. In this case, runoff from the impervious surfaces in the highly urbanized area of the UConn campus such as parking lots, buildings and roads was suspected to be causing the impairments in Eagleville Brook. Therefore, CT DEP approved this TMDL for impervious cover (IC), which is the first of its kind in the nation.

Typical development approaches do not provide adequate treatment for stormwater runoff from impervious areas, and receiving waters suffer a variety of impairments due to these human induced changes in the landscape. Stormwater runoff has been identified as one of the biggest causes of stream quality degradation.

When an undeveloped site is converted into residential housing or commercial areas, roads, roofs, parking lots and driveways replace the native vegetation and soils that were on the site. As would be expected, much more water runs off developed sites in response to rain storms. Pollutants, such as oil from vehicles, bacteria, nitrogen and phosphorus collect on the impervious surfaces and are washed off during precipitation events.

Low impact development (LID) is an approach that will help to minimize the impacts of traditional development, while still allowing for growth. Pioneered in Maryland[1], this approach is being successfully utilized throughout the country. LID has also been adopted as the preferred method of site design in the 2004 Connecticut Stormwater Quality Manual[2]. In addition to protecting ecosystems and receiving waters, the LID approach can often result in cost savings on projects[3].

The following areas of focus will help guide planning for your project:

1. *Assessment of natural resources.* Ideally, LID is considered early in the site planning process. The objective is to allow for development of the property, while maintaining the essential hydrologic functions of the site. A thorough assessment of the existing natural resources on the site needs to be performed, so that essential features can be preserved, and suitable sites for development can be identified.

2. *Preservation of open space.* Open space or conservation subdivision design can complement the LID approach. Conservation subdivisions provide a key way to protect natural resources while still providing landowners with the ability to develop their property. In most cases, the number of residential units allowed in a conservation subdivision equal the number allowed under conventional subdivision regulations.

3. *Minimization of land disturbance.* Once the development envelope is defined, the goal is to minimize the amount of land that needs to be disturbed. Undisturbed forest, meadow, and wetland areas have an enormous ability to infiltrate and process rainfall, providing baseflow to local streams and groundwater recharge. Construction equipment causes severe compaction of soils, so after development, even areas that are thought to be pervious such as grass, can be quite impervious to rainfall.

4. *Reduce and disconnect impervious cover.* With careful planning, the overall percentage of impervious cover in a proposed project can be minimized. Roads, driveways, sidewalks, parking lots, and building footprints can be minimized to reduce impacts, but still provide functionality. Additionally, not all impervious surfaces have the same impact on local waterways. With proper planning, runoff from impervious surfaces can be directed to pervious areas such as grass or forest, or to LID treatment practices.

5. *LID practices installed*. There are a variety of practices that can be used to maintain the pre-development hydrologic function of a site. For more detail on the following practices, see the references below:

-Bioretention areas or rain gardens are depressed areas in the landscape that collect and infiltrate stormwater.

-Vegetated swales can be used to convey runoff instead of the typical curb and gutter system, and they can also infiltrate and filter stormwater.

-Water harvesting techniques can be employed, so that stormwater can be a resource rather than a waste product.

-Pervious pavements allow rainfall to pass through them, and can be installed instead of traditional asphalt or concrete.

-Green roofs can reduce stormwater runoff through evaporation and transpiration through plants, and they also can help save on heating/cooling costs.

LID represents a change from typical design approaches. Proper installation and maintenance of LID practices is critical to their performance. Therefore, installation should be performed by someone with LID experience to avoid costly mistakes.

With proper design and installation, LID can provide multiple benefits including decreased construction costs, reduced impacts to receiving waters, increased habitat for wildlife, beautiful landscape features, and increased property values.

References

[1]Prince George's County, Maryland. 1999. Low-Impact Development Design Strategies: An Integrated Design Approach. MD Department of Environmental Resources, Programs and Planning Division.

[2]CT DEP. 2004. Connecticut Stormwater Quality Manual. Department of Environmental Protection. 79 Elm St., Hartford CT. Available at Mansfield Town Hall, or online at http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325704&depNav_GID=1654

[3]US EPA. 2007. Reducing Stormwater Costs through Low Impact Development (LID), Strategies and Practices. EPA Publication number 841-F07-006.

UConn Low Impact Development (LID) Site Planning and Design Checklist

Items listed below need to be considered by developers in the creation of site plans. Due to individual site differences, not all items will apply to each individual site. Check items that have been applied, or explain why the items have not been used. For more information on LID practices and how to implement them please refer to the 2004 Connecticut Stormwater Quality Manual. Where applicable, references have been made to the appropriate section of the University of Connecticut Campus Sustainable Design Guidelines (SDGs) (JJR & Smithgroup, 2004).

1. **Assessment of Natural Resources** *(See SDGs, page 7, Goal 1)*
   - ☐ Natural resources and constraints have been indicated and are identified on the plans (wetlands, rivers, streams, flood hazard zones, meadows, agricultural land, tree lines, slopes [identified with 2 foot contours], soil types, exposed ledge & stone walls.
   - ☐ Onsite soils have been assessed to determine suitability for stormwater infiltration, and identified on plans.

     See sheet#____

   - ☐ Natural existing drainage patterns have been delineated on the plan and are proposed to be preserved or impacts minimized.
   - ☐ *For items not checked, please use the space below to explain why that item was not appropriate or possible for your project, or any other pertinent information:*

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2. **Minimization of Land Disturbance** *(See SDGs, page 7, Goal 2)*
   - ☐ The proposed building(s) is/are located where development can occur with the least environmental impact (for projects that have NOT had an Environmental Impact Evaluation as required under CT Environmental Policy Act).
   - ☐ Disturbance areas have been delineated to avoid unnecessary clearing or grading.
   - ☐ Plan includes detail on construction methods and sequencing to minimize compaction of natural and future stormwater areas.

- ☐ *For items not checked, please use the space below to explain why that item was not appropriate or possible for your project, or any other pertinent information:*

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3. **Reduce and Disconnect Impervious Cover** *(See SDGs, page 11, Goal 1)*
   - ☐ Impervious surfaces have been kept to the minimum extent practicable, using the following methods (check which methods were used):
     - ☐ Minimized road widths
     - ☐ Minimized driveway area
     - ☐ Minimized sidewalk area
     - ☐ Minimized building footprint
     - ☐ Minimized parking lot area
   - ☐ Impervious surfaces have been disconnected from the stormwater system, and directed to appropriate pervious areas, where practicable. Pervious areas may be LID practices, or uncompacted turf areas.
   - ☐ *For items not checked, please use the space below to explain why that item was not appropriate or possible for your project, or any other pertinent information:*

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4. **LID Practices Installed** *(See SDGs, page 11, Goal 1)*
   - ☐ Sheet flow is used to the maximum extent possible to avoid concentrating runoff.
   - ☐ Vegetated swales have been installed adjacent to driveways and/or roads in lieu of a curb and gutter stormwater collection system.
   - ☐ Rooftop drainage is discharged to bioretention/rain gardens.
   - ☐ Rooftop drainage is discharged to drywell or infiltration trench.
   - ☐ Rain water harvesting methods such as rain barrels or cisterns have been installed to manage roof drainage.
   - ☐ Driveway, roadway, and/or parking lot drainage is directed to bioretention/rain gardens.
   - ☐ Cul-de-sacs include a landscaped bioretention island.
   - ☐ Vegetated roof systems have been installed.

- ☐ Pervious pavements have been installed.
- ☐ *For items not checked, please use the space below to explain why that item was not appropriate or possible for your project, or any other pertinent information:*

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Guidance Document for Low Impact Development

Best Management Practices for Town of Mansfield, CT

April, 2011

Similar to many towns in Connecticut, Mansfield has seen increased interest in balancing community growth and environmental conservation. When an undeveloped site is converted into residential housing or commercial areas, roads, roofs, parking lots and driveways replace the native vegetation and soils that were on the site. As would be expected, much more water runs off developed sites in response to rain storms. Pollutants, such as oil from vehicles, bacteria, nitrogen and phosphorus collect on the impervious surfaces and are washed off during precipitation events. Typical development approaches do not provide adequate treatment for this stormwater, and receiving waters suffer a variety of impairments due to these human induced changes in the landscape. Stormwater runoff has been identified as one of the biggest causes of stream quality degradation.

Low impact development (LID) is an approach that will help to minimize the impacts of traditional development, while still allowing for growth. Pioneered in Maryland[1], this approach is being successfully utilized throughout the country. LID has also been adopted as the preferred method of site design in the 2004 Connecticut Stormwater Quality Manual[2]. In addition to protecting ecosystems and receiving waters, the LID approach can often result in cost savings on projects[3].

The following areas of focus will help guide planning for your project:

1. *Assessment of natural resources.* Ideally, LID is considered early in the site planning process. The objective is to allow for development of the property, while maintaining the essential hydrologic functions of the site. A thorough assessment of the existing natural resources on the site needs to be performed, so that essential features can be preserved, and suitable sites for development can be identified.

2. *Preservation of open space.* Cluster subdivision design can complement the LID approach. Cluster subdivisions provide a key way to protect natural resources while still providing landowners with the ability to develop their property. In most cases, the number of residential units allowed in a cluster subdivision equals the number allowed under conventional subdivision regulations.

3. *Minimization of land disturbance.* Once the development envelope is defined, the goal is to minimize the amount of land that needs to be disturbed. Undisturbed forest, meadow, and wetland areas have an enormous ability to infiltrate and process rainfall, providing

baseflow to local streams and groundwater recharge. Construction equipment causes severe compaction of soils, so after development, even areas that are thought to be pervious such as grass, can be quite impervious to rainfall.

4. *Reduce and disconnect impervious cover.* With careful planning, the overall percentage of impervious cover in a proposed project can be minimized. Roads, driveways, sidewalks, parking lots, and building footprints can be minimized the reduce impacts, but still provide functionality. Additionally, not all impervious surfaces have the same impact on local waterways. With proper planning, runoff from impervious surfaces can be directed to pervious areas such as grass or forest, or to LID treatment practices. It should be noted that every project is unique, and not every LID practice will be appropriate. For example, sidewalks or bike paths may be an asset to a new subdivision, if there is some connection to existing pedestrian travel routes. However, sidewalks may not be needed in other settings, and would add unnecessary costs and impervious cover. The objective is to evaluate each site individually and determine the most appropriate management techniques to reduce impacts to waterways.

5. *LID practices installed*. There are a variety of practices that can be used to maintain the pre-development hydrologic function of a site. For more detail on the following practices, see the references below:

-Bioretention areas or rain gardens are depressed areas in the landscape that collect and infiltrate stormwater.

-Vegetated swales can be used to convey runoff instead of the typical curb and gutter system, and they can also infiltrate and filter stormwater.

-Water harvesting techniques can be employed, so that stormwater can be a resource rather than a waste product.

-Pervious pavements allow rainfall to pass through them, and can be installed instead of traditional asphalt or concrete.

-Green roofs can reduce stormwater runoff through evaporation and transpiration through plants, and they also can help save on heating/cooling costs.

LID represents a change from typical design approaches. Proper installation and maintenance of LID practices is critical to their performance. Therefore, installation should be performed by someone with LID experience to avoid costly mistakes.

With proper design and installation, LID can provide multiple benefits including decreased construction costs, reduced impacts to receiving waters, increased habitat for wildlife, beautiful landscape features, and increased property values.

References

[1]Prince George's County, Maryland. 1999. Low-Impact Development Design Strategies: An Integrated Design Approach. MD Department of Environmental Resources, Programs and Planning Division.

[2]CT DEP. 2004. Connecticut Stormwater Quality Manual. Department of Environmental Protection. 79 Elm St., Hartford CT. Available at Mansfield Town Hall, or online at http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325704&depNav_GID=1654

[3]US EPA. 2007. Reducing Stormwater Costs through Low Impact Development (LID), Strategies and Practices. EPA Publication number 841-F07-006.

Town of Mansfield Low Impact Development (LID) Site Planning and Design Checklist

Items listed below need to be considered by developers when submitting plans for subdivisions. Due to individual site differences, not all items will apply to each individual property. Check items that have been applied, or explain why the items have not been used. For more information on LID practices and how to implement them please refer to the 2004 Connecticut Stormwater Quality Manual.

1. Assessment of Natural Resources

- ☐ Natural resources and constraints have been indicated and are identified on the plans (wetlands, rivers, streams, flood hazard zones, meadows, agricultural land, tree lines, slopes [identified with 2 foot contours], soil types, exposed ledge & stone walls.
- ☐ Is the property shown on the latest copy of CT DEP State and Federal Listed Species and Significant Natural Communities Map as listed in the Natural Diversity Data Base (NDDB)? If so, provide a copy of the CT DEP NDDB request form and CT DEP reply letter.
- ☐ Development is designed to avoid critical water courses, wetlands, and steep slopes.
- ☐ Soils suitable for septic & stormwater infiltration have been identified on plans.
- ☐ Soil infiltration rate/permeability has been measured and listed on plan:

  See sheet#____

- ☐ Onsite soils have been assessed to determine suitability for stormwater infiltration.
- ☐ Natural existing drainage patterns have been delineated on the plan and are proposed to be preserved or impacts minimized.
- ☐ *For items not checked, please use the space below to explain why that item was not appropriate or possible for your project, or any other pertinent information:*

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2. **Preservation of Open Space**
   - ☐ Percent of natural open space calculation has been performed.
     Percent=______________
   - ☐ An open space or cluster subdivision design has been used.
   - ☐ Open space/common areas are delineated.
   - ☐ Open space is retained in a natural condition.
   - ☐ Reduced setbacks, frontages, and right-of-way widths have been used where practicable.
   - ☐ *For items not checked, please use the space below to explain why that item was not appropriate or possible for your project, or any other pertinent information:*

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3. **Minimization of Land Disturbance**
   - ☐ The proposed building(s) is/are located where development can occur with the least environmental impact.
   - ☐ Disturbance areas have been delineated to avoid unnecessary clearing or grading.
   - ☐ Native vegetation outside the immediate construction areas remains undisturbed or will be restored.
   - ☐ Plan includes detail on construction methods and sequencing to minimize compaction of natural and future stormwater areas.
   - ☐ *For items not checked, please use the space below to explain why that item was not appropriate or possible for your project, or any other pertinent information:*

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4. **Reduce and Disconnect Impervious Cover**
   - ☐ Impervious surfaces have been kept to the minimum extent practicable, using the following methods (check which methods were used):
     - ☐ Minimized road widths
     - ☐ Minimized driveway area
     - ☐ Minimized sidewalk area
     - ☐ Minimized cul-de-sacs
     - ☐ Minimized building footprint
     - ☐ Minimized parking lot area
   - ☐ Impervious surfaces have been disconnected from the stormwater system, and directed to appropriate pervious areas, where practicable. Pervious areas may be LID practices, or uncompacted turf areas.
   - ☐ *For items not checked, please use the space below to explain why that item was not appropriate or possible for your project, or any other pertinent information:*

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5. **LID Practices Installed**
   - ☐ Sheet flow is used to the maximum extent possible to avoid concentrating runoff.
   - ☐ Vegetated swales have been installed adjacent to driveways and/or roads in lieu of a curb and gutter stormwater collection system.
   - ☐ Rooftop drainage is discharged to bioretention/rain gardens.
   - ☐ Rooftop drainage is discharged to drywell or infiltration trench.
   - ☐ Rain water harvesting methods such as rain barrels or cisterns have been installed to manage roof drainage.
   - ☐ Driveway, roadway, and/or parking lot drainage is directed to bioretention/rain gardens.
   - ☐ Cul-de-sacs include a landscaped bioretention island.
   - ☐ Vegetated roof systems have been installed, if appropriate.
   - ☐ Pervious pavements have been installed, if appropriate.

For items not checked, please use the space below to explain why that item was not appropriate or possible for your project, or any other pertinent information:

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APPENDIX B. Potential Retrofit Sites on UConn Campus, with Load Reduction and Cost Estimates.

Site ID	Location	Retrofit	DA IC (acres)	Cost[3]	TP Removed (lb/yr)	TN Removed (lb/yr)	TSS Removed (lb/yr)	Runoff Reduction (%)	Annual Runoff Reduction (cf/yr)
A3	F Lot	Terraced bioretention	1.64	$89,000	2.3	20.0	500	20%	51,950
A4	F Lot	Bioretention	1.13	$41,000	1.6	13.8	346	40%	25,350
A5a	Motor Pool	Sand filter	1.33	$56,000	1.3	4.6	213	0%	0
A5b	Central Warehouse	Green roof	0.93	$545,400	1.1	8.0	285	45%	66,400
A8a	Hurley Hall	Bioretention	0.47	$4,800	0.2	1.6	41	40%	8,450
A8b	Hurley Hall	Rain gardens	0.20	$15,900	0.2	1.9	47	40%	8,400
A8c	Hurley Hall	Rain gardens	0.18	$22,800	0.3	2.7	67	40%	11,400
A11a-d	Lot 9	Bioretention & grass swale	1.39	$51,600	1.9	16.0	410	10% (grass swale) 40% (bioretention)	0
B3	Baseball Field Batting Cage	Gravel Wetland	15.11	$250,100	13.3	49.2	2263	0%	0
B5a	Parking Lot Y	Swale to Bioretention	1.32	$43,500	1.7	14.6	367	60%	113,250
B5b	Parking Lot Y	Swale to Bioretention	0.50	$18,300	0.7	6.1	155	60%	47,300
B11a	Parking Lot W	Bioretention	0.86	$27,200	1.1	9.1	230	60%	70,900

Table 4. High Priority Projects

[3] Cost reflects an estimate of construction costs only and does not include further design and engineering.

Table 4. High Priority Projects									
Site ID	**Location**	**Retrofit**	**DA IC** (acres)	**Cost**[3]	**TP Removed** (lb/yr)	**TN Removed** (lb/yr)	**TSS Removed** (lb/yr)	**Runoff Reduction** (%)	**Annual Runoff Reduction** (cf/yr)
B11b	Parking Lot W	Bioretention	1.38	$32,600	1.3	11.0	275	60%	82,000
B11c	Parking Lot W	Swale to Bioretention	1.02	$33,800	1.3	11.4	286	60%	87,250
B11d	Parking Lot W	Bioretention	0.92	$33,500	1.3	11.3	283	60%	87,250
C4e	School of Education	Bioretention	0.34	$12,400	0.5	4.2	105	40%	21,350
C4/5a	GENT	Stormwater planters	0.12	$10,500	0.2	1.4	36	40%	7,400
C4/5d	GENT	Bioretention	0.07	$2,600	0.1	0.9	22	40%	4,650
C16	Torrey Life Sciences	Bioretention	0.28	$10,300	0.4	3.5	87	40%	17,950
C17	Quad in front of chemistry bldg	Bioretention	0.51	$18,600	0.7	6.2	157	40%	32,400
C18	Eagleville Rd	Bioretention	0.85	$30,700	1.2	10.3	259	40%	53,950
Total			***30.5***	***$1,350,600***	***32.5***	***207.5***	***6433***	**--**	***797,600***

Site A-5: Warehouse and Motor Pool

Perimeter Sand Filter/ Green Roof at Stormwater Hotspots

Project Summary

Parameter	A-5a	A-5b
Impervious Cover Treated (acres)	1.33	0.93
Runoff Reduction Volume (cu ft per 1" rain event)	0	1,444
TN Removal (lb/yr)	4.63	8.0
TP Removal (lb/yr)	1.25	1.1
TSS Removal (lb/yr)	212.96	284
Estimated Cost	$56,000	$545,400

Site Description

The proposed retrofit concept is located on the UConn Campus at the motor pool and warehouse east of the facilities building (Figure 1). The motor pool's parking area is entirely impervious, with some indications of oil spillage near the fueling area. The warehouse has a large, flat roof.

Existing Conditions

Runoff from this site is captured in an enclosed storm drain system. Although there appears to be a trap to capture drainage from inside the building, presumably leading to the sanitary sewer system, there is currently no stormwater treatment on the site. Consequently, the potential for automotive contaminants (i.e., oil, antifreeze, brake fluid) to come into contact with stormwater is high (Figure 2).

Proposed Concept

Install a perimeter sand filter to capture motorpool parking lot runoff (Site A5a), and a green roof on the rooftop (Site A5b). Convey overflow from these practices to the existing storm drain system.

Figure 1. Drainage areas to two proposed practices, a sand

filter (A5-a) and green roof (A-5b).

Figure 2. Motorpool parking lot (top) and existing external

rooftop drains from warehouse to storm drain (lower).

Preliminary Concept Designs

A 25% concept design for the proposed retrofit can be found in attachment B, which includes preliminary plan views, cross sections and project details. These initial plans will require field survey

and more information on drainage pipes and utilities before going to construction plans.

Preliminary Hydrologic Calculations

Preliminary sizing was completed based on guidance provided in the *2004 Connecticut Stormwater Quality Manual*. These computations are summarized in the following table.

Sizing Calculations for Sites A-5a/b		
Parameter	Value	
	A-5a	A5-b
Drainage Area, A (acres)	0.92	0.93
Imperviousness, I (%)	97	100
Volumetric Runoff Coefficient, Rv	0.92	0.95
Rainfall Depth, P (in)	1	1
Water Quality Volume, WQv (cf)	4,600	3,208
Porosity	–	0.4
Depth of the Filter Bed, d (ft)	1.5	--
Hydraulic Conductivity, k (ft/day)	3.5	
Max. Ponding Depth, hmax (in)	12	
Average Ponding Depth, h (ft)	0.5	
Drawdown Time, t (days)	1	
Surface Area Required, Af (sq. ft)	986	
Media Depth Required (in)	–	2.5
Surface Area Provided (sq ft)	600	40,520
Treatment Provided (% of 1")	61	100

Design Considerations

For site A-5a, the depths and locations of storm drainage needs to be confirmed. Available storm drain infrastructure maps suggest that no storm drains exist within the parking lot, or in the adjacent road, but field investigations indicate at least one storm drain structure in the parking lot, and an additional structure near the entrance of the lot treated by practice A-5a. Mapping needs to be validated.

In addition, the filter at site A-5a is relatively close to mapped water and electric lines. The specific location of these utilities needs to be verified in the field.

For site A-5b, the roof's structural integrity needs to be verified to confirm that a green roof is a feasible option. Lessons learned from other green roof installations on campus should be incorporated into planning, construction, and long-term maintenance.

Maintenance

The routine maintenance activities typically associated with sand filters (A-5a) and green roofs (A-5b) are summarized in the tables below.

Maintenance Activities for Sandfilters	
Activity Schedule	Frequency
• Remove blockages and obstructions from inflows. • Relieve clogging. • Stabilize contributing drainage area and side-slopes to prevent erosion.	As Needed (following construction)
• Inspection and cleanup.	Annually
• Cleanout wet sedimentation chambers.	Every 2 to 3 Years
• Replace top sand layer.	Every five years

Maintenance Activities for Green Roofs	
Activity Schedule	Frequency
• Water to promote plant growth and survival. • Inspect the green roof and replace any dead or dying vegetation.	As Needed (Following Construction)
• Inspect the waterproof membrane for leaking or cracks. Repair as needed. • Inspect outflow and overflow areas for sediment accumulation. Remove any accumulated sediment or debris. • Inspect the green roof for dead, dying, or invasive vegetation. Plant replacement vegetation as needed.	Semi-Annually (Quarterly During First Year)

Site A3/4: F Lot

Terraced Parking Lot Bioretention

Project Summary

Parameter	A3	A4
Impervious Cover Treated (acres)	1.64	1.13
Runoff Reduction Volume (cu ft per 1" rain event)[1]	1130	550
TN Removal (lb/yr)	19.91	13.75
TP Removal (lb/yr)	2.31	1.6
TSS Removal (lb/yr)	500.81	345.9
Estimated Cost	$89,000	$41,000

[1] Although this project has no actual infiltration a reduced level of runoff reduction is calculated to account for extended filtration and evapotranspiration.

Figure 1. Drainage areas to proposed bioretention cells.

Site Description

The proposed retrofit concept is located on the UConn Campus in the F Lot. The site is a terraced parking lot, with an upper and lower parking area separated by a grassed slope (Figure 1). The site is over a former landfill with an impervious cap.

Existing Conditions

Runoff from both lots is captured in an enclosed storm drain system, which discharges directly to Eagleville Brook. Grassed areas, including a sloped island between the upper and lower parking areas and below the lower parking area, currently receive no runoff from the parking lot.

Proposed Concept

Install two bioretention areas, one in the sloped island between the upper and lower parking area (Site A3), and one below the lower parking area (Site A4). Figure 2 shows locations of proposed practices as seen in the field. Convey runoff to each practice using paved flumes. Each of the filters will allow 6-9" of ponding depth above the filter. Two bioretention filters, constructed in fill (i.e., above the landfill cap) will capture runoff from the upper parking lot. The filter bed will be sloped, ranging from 6" to 18", constructed above the existing grade. An underdrain will be installed at the lower

Figure 2. Location of terraced A3 bioretention down slope between two parking areas (upper photo), Location of A4 bioretention cell near entrance to parking lots (lower photo).

end of each filter. This underdrain will tie into an overflow structure which will then convey stormwater to a very deep storm drain system.

At the lower site A4, the practice will be excavated to a filter depth of 12", then captured in an underdrain and conveyed to Eagleville Brook. The site overflow for this practice is a spillway which allows overland flow to the Brook.

Preliminary Concept Designs
A 25% concept design for the proposed retrofit can be found in attachment B, which includes preliminary plan views, cross sections and project details. These initial plans will require field survey and more information on drainage pipes, utilities, and soils (among other things) before going to construction plans.

Preliminary Hydrologic Calculations
Preliminary sizing of the bioretention area was completed based on guidance provided in the *2004 Connecticut Stormwater Quality Manual*. These computations are summarized in the following table.

Sizing Calculations for Sites A3/A4		
Parameter	Value	
	A3	A4
Drainage Area, A (acres)	1.64	1.13
Imperviousness, I (%)	100	100
Volumetric Runoff Coefficient, Rv	0.95	.95
Rainfall Depth, P (in)	1	1
Water Quality Volume, WQv (cf)	5,648	3,901
Depth of the Filter Bed, d (ft)	1	1
Hydraulic Conductivity, k (ft/day)	1	1
Max. Ponding Depth, hmax (in)	9	9
Average Ponding Depth, h (ft)	0.375	0.375
Drawdown Time, t (days)	2	2
Surface Area Required, Af (sq. ft)	2,054	1,418
Surface Area Provided (sq ft)	3,125	500
Treatment Provided (% of 1")	100	35

Design Considerations
For site A3, the greatest design constraint is the landfill cap below the filter proposed in the sloped median between the two parking areas. The proposed design assumes that the filter is completely in fill, with the bottom of the filter adjacent to the existing ground surface. Designers should investigate the possibility of excavating slightly into the landfill cap, providing a flat filter bottom at a depth of 18".

Three potential constraints need to be investigated:

- Electric lines are in the vicinity of the proposed filter, and their locations need to be confirmed.
- The filter is shallow due to potentially high groundwater table. Need to confirm depth of high groundwater.
- Available mapping suggest that the landfill cap does not extend to this area of the F Lot site. Need to confirm.

Maintenance
Maintenance is important for bioretention areas, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. The routine maintenance activities typically associated with bioretention areas are summarized in the table below.

Maintenance Activities for Sites A3/4	
Activity Schedule	Frequency
• Water once a week during the first two months, and then as needed and depending on rainfall to promote plant growth and survival. • For the first six months following construction, the site should be inspected at least twice after storm events that exceed a half-inch. Inspectors should look for bare or eroding areas in the contributing drainage area or around the bioretention area, and ensure they are immediately stabilized with grass cover.	As Needed (following construction)
• Prune and weed bioretention area to maintain appearance. • Remove accumulated trash and debris.	Regularly (Monthly)
• Inspect inflow area for sediment accumulation and remove any accumulated sediment or debris. • Inspect bioretention area for dead or dying vegetation. Plant replacement vegetation as needed.	Annually
• Remove and replace existing mulch	Every 2 to 3 Years

Site A8: Hurley Hall

Rooftop Disconnection with Bioretention

Project Summary

Parameter	A8a	A8b	A8c
Impervious Cover Treated (acres)	0.51	0.81	0.88
Runoff Reduction Volume (cu ft per 1" rain event)	184	212	304
TN Removal (lb/yr)	1.62	1.86	2.68
TP Removal (lb/yr)	0.19	0.21	0.31
TSS Removal (lb/yr)	40.79	46.9	67.39
Estimated Cost	$4,900	$15,900	$22,800

Site Description

The proposed concepts are located in the quad area of the Hurley Hall Student Residences, which are located on the UConn Campus on the north side of N Eagleville Road. The quad area is terraced and slopes toward Eagleville Rd.

Existing Conditions

Runoff from the walkways along the quad area drain to the central grass quad area. Gully erosion is evident in the quad area and along walkways, and sand and gravel has accumulated on the paths. Yard inlets in the quad area are full of sediment. Rooftop runoff from the residences is conveyed via internal roofdrains in the storm drain system.

Proposed Concept

Install bioretention areas in three locations in the quad area to capture walkway runoff. These three locations are shown in Attachment B. Install trench drains across the walkway to intercept runoff and convey it into the bioretention practices.

Construct a forebay area at the bioretention inlets to dissipate the energy and velocity of the runoff entering the bioretention areas. The bioretention areas should have a filter depth of 24 inches and provide 6-9 inches of ponding depth.

Figure 1. Runoff from quad walkways resulting in erosion (top); Sediment accumulation on walkways and in quad area (bottom).

Due to the compacted nature of the quad soils, an underdrain should be included in the design of the larger bioretention areas. The underdrain and overflow should tie into existing yard drains. The smaller areas in the center of the quad can be designed to overflow into existing yard inlets.

Soils in the quad should be amended as shown on the site plan to improve porosity and infiltration. Landscaping can be incorporated into these amended areas.

Preliminary Concept Designs

25% concept designs for the proposed retrofit can be found in attachment B. Preliminary plan views and project details are included. These initial plans will need to be further refined as this project proceeds towards construction.

Preliminary Hydrologic Calculations

Preliminary sizing of the bioretention area was completed based on guidance provided in the *2004 Connecticut Stormwater Quality Manual*. These computations are summarized in the table below.

Sizing Calculations for Site A8			
Parameter	Value		
	A8a	A8b*	A8c
Drainage Area, A (acres)	0.51	0.81	0.88
Imperviousness, I (%)	92	51	21
Volumetric Runoff Coefficient, Rv			
Rainfall Depth, P (in)	1	1	1
Water Quality Volume, WQv (cf)	1631	798	760
Depth of the Filter Bed, d (ft)	2.5	2.5	2.5
Hydraulic Conductivity, k (ft/day)	1	1	1
Max. Ponding Depth, hmax (in)	9	9	9
Average Ponding Depth, h (ft)	0.375	0.375	0.375
Drawdown Time, t (days)	2	2	2
Surface Area Required, Af (sq. ft)	709	347	330
Surface Area Provided (sq ft)	200	230	400
Treatment Provided (% of 1")	28.2	66.3	100
*note two bioretention areas are combined			

Design Considerations

- While utility constraints are expected to be minimal, detailed utility mapping should be obtained before completing the final project design.
- This project presents an opportunity for students and faculty at Uconn to be involved in the final design and construction of this project.

Maintenance

- Maintenance is important for bioretention areas, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. The routine maintenance activities typically associated with bioretention areas are summarized in the table below.

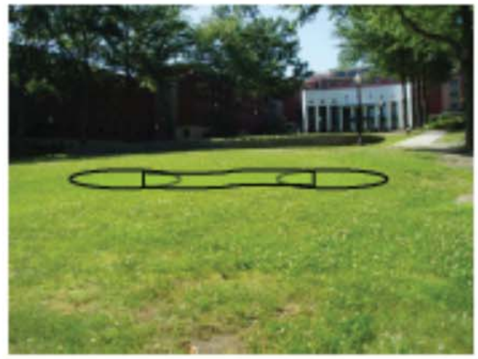

Figure 2. Proposed location of bioretention areas at site A8b (top) and A8c (bottom).

Maintenance Activities for Bioretention	
Activity Schedule	Frequency
• Water once a week during the first two months, and then as needed and depending on rainfall to promote plant growth and survival. • For the first six months following construction, the site should be inspected at least twice after storm events that exceed a half-inch. Inspectors should look for bare or eroding areas in the contributing drainage area or around the bioretention area, and immediately stabilized with grass cover.	As Needed (following construction)
• Prune and weed bioretention area to maintain appearance. • Remove accumulated trash and debris.	Regularly (Monthly)
• Inspect inflow area for sediment accumulation and remove any accumulated sediment or debris. • Inspect bioretention area for dead or dying vegetation. Plant replacement vegetation as needed.	Annually
• Remove and replace existing mulch	Every 2 to 3 Years

Site C17/C16: Chemistry Building Quad

Rooftop Disconnection with Bioretention

Parameter	C17a/b	C16
Impervious Cover Treated (acres)	0.51	0.28
Runoff Reduction Volume (cu ft per 1" rain event)	707	115
TN Removal (lb/yr)	6.23	3.46
TP Removal (lb/yr)	0.72	0.4
TSS Removal (lb/yr)	156.7	87.07
Estimated Cost	$18,600	$10,300

Site Description

The proposed concept is located on the UConn Campus in a quad area between the Chemistry Building and the Pharmacy/Biology Building. The quad is grassed and contains a few small trees, but otherwise lacks landscaping. Soils are extremely compacted, and several dirt and concrete pathways traverse the area. The perimeter is characterized by bare soils and sediment deposition.

Existing Conditions

Runoff from the Chemistry building rooftop is conveyed underground and into the stormdrain system via external roof drains. Yard drains located in the quad area capture surface runoff from the quad and adjacent impervious areas (paved pathways, driving lanes, and wide sidewalks). On the northwest corner of the quad, runoff from the Life Sciences parking lot is conveyed to an inlet located along the quad. Runoff from these areas is conveyed directly to Eagleville Brook, which is piped deep underneath the quad area, approximately 20-22' below grade.

Proposed Concept

Install three bioretention areas in the quad area to capture rooftop and impervious area runoff. Direct the external roof downspouts from the Chemistry Building to the proposed bioretention areas by

Figure 1. Drainage area (top); External roof drains and proposed retrofit locations for bioretention areas with forebays in the grassy quad area adjacent to the Chemistry Building (middle), location of C16 (bottom).

installing a new pipe to convey the roof runoff from a portion of the building.

Construct a forebay area at the pipe outlet to dissipate the energy and velocity of the runoff entering the bioretention areas. Runoff from the adjacent impervious areas can enter the bioretention areas via sheetflow. The bioretention areas should have a filter depth of 24 inches and provide 6-9 inches of ponding depth. Due to the compacted nature of the soils, an underdrain is needed for the design. The underdrain and overflow should tie into existing yard drains.

Preliminary Concept Designs

25% concept designs for the proposed retrofit can be found in attachments B. Preliminary plan views and project details are included. These initial plans will need to be further refined as this project proceeds towards construction.

Preliminary Hydrologic Calculations

Preliminary sizing of the bioretention area was completed based on guidance provided in the *2004 Connecticut Stormwater Quality Manual*. These computations are summarized in the table below.

Sizing Calculations for Site C-17/16		
Parameter	Value	
	C17a/b*	C16
Drainage Area, A (acres)	0.55	0.32
Imperviousness, I (%)	92.8	88.7
Volumetric Runoff Coefficient, Rv	0.89	0.85
Rainfall Depth, P (in)	1	1
Water Quality Volume, WQv (cf)	1767	982
Depth of the Filter Bed, d (ft)	2.50	2.5
Hydraulic Conductivity, k (ft/day)	1	1
Max. Ponding Depth, hmax (in)	9	9
Average Ponding Depth, h (ft)	0.375	0.375
Drawdown Time, t (days)	2	2
Surface Area Required, Af (sq. ft)	768	427
Surface Area Provided (sq ft)	1145	500
Treatment Provided (% of 1")	100	29
*note two bioretention areas are combined		

Design Considerations

- There is a building below the quad which may limit the size and extent of concept.
- While utility constraints are expected to be minimal, detailed utility mapping should be obtained before completing the final project design. The main stormdrains are 20-22' below grade and may not constrain the project, however, there may be shallower connection pipes that will need to be avoided.
- This project presents an opportunity for students and faculty at Uconn to be involved in the final design and construction of this project.

Maintenance

Maintenance is important for bioretention areas, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. The routine maintenance activities typically associated with bioretention areas are summarized in the table below.

Maintenance Activities for Bioretention	
Activity Schedule	Frequency
• Water once a week during the first two months, and then as needed and depending on rainfall to promote plant growth and survival. • For the first six months following construction, the site should be inspected at least twice after storm events that exceed a half-inch. Inspectors should look for bare or eroding areas in the contributing drainage area or around the bioretention area, and immediately stabilized with grass cover.	As Needed (following construction)
• Prune and weed bioretention area to maintain appearance. • Remove accumulated trash and debris.	Regularly (Monthly)
• Inspect inflow area for sediment accumulation and remove any accumulated sediment or debris. • Inspect bioretention area for dead or dying vegetation. Plant replacement vegetation as needed.	Annually
• Remove and replace existing mulch	Every 2 to 3 Years

Site C-18: North Eagleville Road

Integrating Stormwater, Landscaping, and Traffic Calming Measures

Project Summary

Parameter	C18
Impervious Cover Treated (acres)	1.25 acres
Runoff Reduction Volume (cu ft per 1" rain event)	881
TN Removal (lb/yr)	7.76
TP Removal (lb/yr)	0.9
TSS Removal (lb/yr)	195.23
Estimated Cost	$23,100

Figure 1. Drainage area (top) and proposed location(s) of street filter designs along North Eagleville Road.

Site Description

The proposed retrofit concept is located on the UConn Campus along North Eagleville Road. This road runs through campus and separates Central Campus and Swan Lake from North Campus, several student housing residences, and privately owned churches (Figure 1).

Existing Conditions

Runoff from the crowned roadway drains to catch basins that are located along the edge of the street. The existing roadway is very wide, up to 44 feet from curb to curb in some locations. The University has expressed concern over a dangerous situation with high pedestrian and vehicle traffic along this roadway, and has taken action by painting no driving areas along the edge of the roadway in an attempt to slow car traffic. Some of these areas are used in the project design.

Proposed Concept

In select areas along the edge of the roadway, remove impervious cover and install street planter areas. These areas should contain a perimeter 6" curb and curb cuts installed to direct the roadway runoff into these areas. The planter areas should provide 6 inches of ponding depth as measured from the roadway surface to the low point in the filter surface. The filter media depth should be 6-12 inches deep. An underdrain is needed for the design of each street filter. The underdrain and overflow should tie into the stormwater network.

Figure 2. Remove pavement along existing road shoulder to edge of existing curb (top). Example street planters with curb cuts from Portland, OR (bottom).

Preliminary Concept Designs

A 25% concept design for the proposed retrofit can be found in attachment B, which includes preliminary plan views, cross sections and project details. These initial plans will require field survey and more information on drainage pipes, utilities (among other things) before going to construction plans.

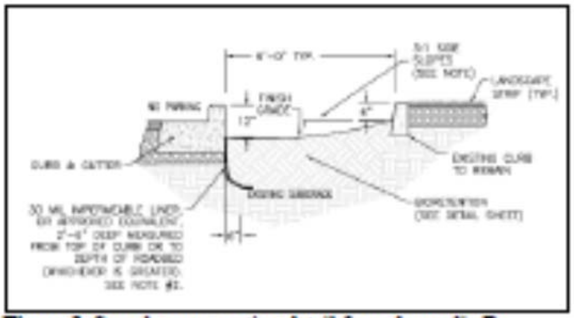

Figure 3. Sample cross section detail from Appendix B.

Preliminary Hydrologic Calculations

Preliminary sizing of the street filter area was completed based on bioretention guidance provided in the *2004 Connecticut Stormwater Quality Manual*. These computations are summarized in the table below.

Sizing Calculations for Site C-18	
Parameter	**Value**
Drainage Area, A (acres)	1.25
Imperviousness, I (%)	100
Volumetric Runoff Coefficient, Rv	0.95
Rainfall Depth, P (in)	1
Water Quality Volume, WQv (cf)	4,300
Depth of the Filter Bed, d (ft)	2.50
Hydraulic Conductivity, k (ft/day)	1
Max. Ponding Depth, hmax (in)	6
Average Ponding Depth, h (ft)	0.25
Drawdown Time, t (days)	1
Surface Area Required, Af (sq. ft)	*3909*
Surface Area Provided (sq ft)	2,000
Treatment Provided (% of 1")	51

Design Considerations

- While utility constraints are expected to be minimal, detailed utility mapping should be obtained before completing the final project design.
- At cross walk areas, pedestrian bridges can be incorporated into the design so that people can cross over the street filter area.
- Current concept design sets a 24' road width, uniform along Eagleville rd. Wider road (and bike lanes) can be obtained by either narrowing the filters themselves or expanding into the sidewalk.
- Designs can serve to calm traffic along the roadway. This project should be integrated with University efforts to calm traffic along the road and also with the Sasaki Landscape Plan.

Maintenance

Maintenance is important for these street filter areas, particularly in terms of ensuring that they contime to provide measurable stormwater management benefits over time. The routine maintenance activities typically associated with bioretention areas are summarized in the table below.

Maintenance Activities for site C-18	
Activity Schedule	**Frequency**
• Water once a week during the first two months, and then as needed and depending on rainfall to promote plant growth and survival. • For the first six months following construction, the site should be inspected at least twice after storm events that exceed a half-inch. Inspectors should look for bare or eroding areas in the contributing drainage area or around the street filter area, and make sure they are immediately stabilized. • Trim trees to prevent line of sight issues.	As Needed (following construction)
• Prune and weed the filter area to maintain appearance. • Remove accumulated trash and debris.	Regularly (Monthly)
• Inspect inflow area for sediment accumulation and remove any accumulated sediment or debris. • Inspect filter area for dead or dying vegetation. Plant replacement vegetation as needed.	Annually
• Remove and replace existing mulch	Every 2 to 3 Years

Site A-11: Lot 9

Parking Lot Bioretention

Project Summary

Parameter	A11a-d
Impervious Cover Treated (acres)	1.39 acres
Runoff Reduction Volume (cu ft per 1" rain event)	1,538 cf
TN Removal (lb/yr)	16.02 lb/yr
TP Removal (lb/yr)	1.90 lb/yr
TSS Removal (lb/yr)	409.61 lb/yr
Estimated Cost	$51,700

Site Description

The proposed retrofit concept is located on the UConn Campus in Lot 9, across from the Visitors Center. The parking lot is heavily used, and in relatively poor condition.

Existing Conditions

Runoff from the site is captured in an enclosed storm drain system, and conveyed to the north. Small landscaped areas to the north receive no drainage from the lot or other impervious areas.

Proposed Concept

Install linear bioretention areas (grassed swales) in medians between existing parking areas. Convey stormwater to these swales using curb cuts. Install 6" check dams along the swale. Existing storm drain structures will act as overflow for large storm events.

Construct two small bioretention cells in the existing landscaped areas. Use curb cuts to receive direct parking lot runoff. In addition, capture small storm runoff from swales in the median via a 6" dip within the swale. Yard drains in these structures will be tied in to existing storm drain structures in the road.

Figure 1. Total drainage area to proposed retrofit practices in Lot 9.

Figure 2. Current parking configuration looking north

(above), and existing northeast landscaped area to be converted to bioretention (below).

Preliminary Concept Designs

A 25% concept design for the proposed retrofit can be found in attachment B, which includes preliminary plan views, cross sections and project details. These initial plans will need to be further refined as this project proceeds towards construction.

Preliminary Hydrologic Calculations

Preliminary sizing of the bioretention area was completed based on guidance provided in the *2004 Connecticut Stormwater Quality Manual*. These computations are summarized in the following table.

Sizing calculations for Site A11		
Parameter	Value*	
	A-11c/d (Swales)	A-11a/b (Bio)
Drainage Area, A (acres)	1.41	1.41
Imperviousness, I (%)	98	98
Volumetric Runoff Coefficient, Rv	0.93	0.93
Rainfall Depth , P (in)	1	1
Water Quality Volume, WQv (cf)	4,790	4,790
Depth of the Filter Bed, d (ft)	–	2.5
Bottom width (ft)	2	–
Side slopes	3:1	--
Hydraulic Conductivity, k (ft/day)	–	1
Drawdown Time, t (days)	–	2
Max. Ponding Depth, hmax (in)	–	9
Average Ponding Depth, h (ft)	0.5	0.375
Cross-Sectional Area (ft)	1.75	–
Length Required (ft)	*2,740*	--
Length Provided (ft)	650	–
Surface Area Required, Af (sq ft)	–	1,495
Surface Area Provided (sq ft)	–	1,550
Treatment Provided (% of 1")	24	75
*Note: Table summarizes total length of both swales and bios		

Design Considerations

Some key design considerations include the following:

- Confirm location of underground electric lines at northeast filter area.
- The proposed filters will require a parking lot reconfiguration. Angled parking, combined with one-way traffic, may be needed to accommodate these swales.
- Available mapping does not indicate how storm drainage from the parking lot connects to the storm drain network in the street and needs to be field-verified.
- The Sasaki Landscaping Plan indicates that tree plantings at the eastern edge of Lot 9 may reduce the lot size. This design does not account for that parking lot loss. An alternative design may utilize only one swale, or an alternative to parking lot swales, such as parking lot tree planters.

Maintenance

Maintenance is important for bioretention areas and grassed swales. The routine maintenance activities typically associated with bioretention areas are summarized in the following tables below.

Maintenance Activities for Site A-11	
Activity Schedule	Frequency
• Water once a week during the first two months, and then as needed and depending on rainfall to promote plant growth and survival. • For the first six months following construction, the site should be inspected at least twice after storm events that exceed a half- inch. Inspectors should look for bare or eroding areas in the contributing drainage area or around the bioretention area, and make sure they are immediately stabilized with grass cover.	As Needed (following construction)
• Prune and weed bioretention area to maintain appearance. • Remove accumulated trash and debris.	Regularly (Monthly)
• Inspect inflow area for sediment accumulation and remove any accumulated sediment or debris. • Inspect bioretention area for dead or dying vegetation. Plant replacement vegetation as needed.	Annually
• Remove and replace existing mulch.	Every 2 to 3 Years

Site B5: Parking Lot Y

Managing Parking Lots with Bioswales

Project Summary

Parameter	*B5a*	*B5b*
Impervious Cover Treated (acres)	1.32	0.5
Runoff Reduction Volume (cu ft per 1" rain event)	2,485	1,044
TN Removal (lb/yr)	14.6	6.13
TP Removal (lb/yr)	1.69	0.71
TSS Removal (lb/yr)	367.18	154.29
Estimated Cost	$43,500	$18,300

Site Description

The proposed retrofit sites are located in the grassed area along the western edge of Parking Lot Y on the UConn campus. The Y Lot is a large parking lot (upper lot) currently draining to existing inlets that discharge toward Lot 8 then, ultimately, towards Site B3 (proposed gravel based wetland).

Existing Conditions

The entire lot (2.2 acres) drains towards the western edge of the parking area to one of two inlets along the curb (~1.8 impervious acres). These inlets convey stormwater northward to an underground detention pipe system with an offline Vortechnic device (WQ Unit) in Lot 8.* Snow storage for Lot Y is over the hill and results in large sand deposits beyond the parking lot edge.

***Lot 8 surface drainage appears to bypass inlets at low end of parking lot, likely contributing to slope damage of reinforced slope.**

Proposed Concept

Remove existing curb at each side of double inlets and install paved flumes to allow surface drainage from parking lot to enter forebays of two bioretention cells excavated in existing grassed areas (Sites A and B, Figure 1). Install curb cuts/paved flumes at other strategic locations to better distribute runoff into practices (Figure 2). Bioretention designed with sediment forebays, underdrains, and an overflow mechanism back into existing inlets (Figure 3).

Figure 1. Drainage areas to two proposed bioretention cells.

Figure 2. Proposed location of bioretention/swale system in grassed edge of Parking Lot Y. Curb cuts allow inflow to forebays at strategic locations along system.

Figure 3. Remove curb along sides of double inlets to allow surface runoff into bioretention area through paved flume with riprap channel. Primary overflow where ponded water "backs up" into existing inlet (blue arrow).

Emergency spillways provided (into wooded area). Use shallow swales along full length of parking lot to convey flow to bioretention. Use riprap channels to convey runoff from curb cuts/paved flume to small pretreatment forebays and to dissipate the energy and velocity of runoff. Existing inlet acts as primary overflow and emergency spillway provided for overflow into wooded slope. The bioretention areas should have a filter depth of 24 inches and provide 6-9 inches of ponding depth. Due to the compacted nature of the soils, include an underdrain that ties back into the existing drains.

Preliminary Concept Designs

A 25% concept design for the proposed retrofit can be found in attachment B, which includes preliminary plan views, cross sections and project details. These initial plans will require field survey and more information on drainage pipes, utilities, and soils (among other things) before going to construction plans.

Preliminary Hydrologic Calculations

Preliminary sizing of the bioretention area was completed based on guidance provided in the *2004 Connecticut Stormwater Quality Manual*. These computations are summarized in the table below.

Sizing calculations for Site B5

Parameter	Value	
	B5a	B5b
Drainage Area, A (acres)	1.5	0.6
Imperviousness, I (%)	85	77
Volumetric Runoff Coefficient, Rv	0.82	0.74
Rainfall Depth, P (in)	1	1
Water Quality Volume, WQv (cf)	4591	1740
Depth of the Filter Bed, d (ft)	2.50	2.50
Hydraulic Conductivity, k (ft/day)	1	1
Max. Ponding Depth, hmax (in)	9	9
Average Ponding Depth, h (ft)	0.375	0.375
Drawdown Time, t (days)	2	2
Surface Area Required, Af (sq. ft)	1996	757
Surface Area Provided (sq ft)	1800	1500
Treatment Provided (% of 1")	90	100

Design Considerations

- A retrofit of the Y Lot would help reduce the volume ultimately discharging to Site B-3.
- Possible conflict with electric cables and existing light pole(s).
- Compare feasibility of various design alternatives for raising exiting inlet structures.
- Incorporate educational signage.

Maintenance

Maintenance is important for bioretention areas, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. The routine maintenance activities typically associated with bioretention areas are summarized in the table below.

Maintenance Activities

Activity Schedule	Frequency
• Water once a week during the first two months, and then as needed and depending on rainfall to promote plant growth and survival. • For the first six months following construction, the site should be inspected at least twice after storm events that exceed a half-inch. Inspectors should look for bare or eroding areas in the contributing drainage area or around the bioretention area, and make sure they are immediately stabilized with grass cover.	As Needed (following construction)
• Prune and weed bioretention area to maintain appearance. • Remove accumulated trash and debris.	Regularly (Monthly)
• Inspect inflow areas/forebays for sediment accumulation and remove any accumulated sediment or debris. • Inspect bioretention area for dead or dying vegetation. Plant replacement vegetation as needed.	Annually
• Remove and replace existing mulch.	Every 2 to 3 Years

Cost Considerations

Added costs if new overflow inlets are required; relocation of electrical lighting a possibility.

Site B3: Christian Field/Batting Cages

Gravel-based Wetland Systems

Project Summary

Parameter	B3
Impervious Cover Treated (acres)	15.1 acres
Runoff Reduction Volume (cu ft per 1" rain event)	0
TN Removal (lb/yr)	49.19
TP Removal (lb/yr)	13.28
TSS Removal (lb/yr)	2,262.73
Estimated Cost	$250,100

Site Description

The proposed retrofit concept is located by the baseball fields and batting cages in the southeastern portion of the UConn Campus.

Existing Conditions

Existing drainage pipe system collects runoff from pervious and impervious surfaces for 55 acre drainage area and discharges into Red Brook (Figure 1). Existing 24 inch pipe runs along open field areas with inlets, likely under baseball field and across Stadium Road. Some of this area is currently managed by upgradient stormwater BMPs. Because a portion of this conveyance appears to have been a former stream, there is likely a shallow depth to groundwater. The location of inlets or manholes in the vicinity of the site were not found. The pipe invert at the outfall is less than 5 feet.

Proposed Concept

Proposed installation of a gravel based wetland system with forebay, designed offline with approximately 5,050 sq ft of available surface area (Figure 2). Use a diversion manhole to divert flows from existing drain line into pretreatment forebay with outlet structure that discharges into bottom of chambered, gravel wetland system. Flows are forced up through gravel filters to a vegetated wetland surface where additional pollutants can be removed via plant uptake. Overflow from the wetland is discharged back into existing stormdrain. An emergency spillway drains into existing low area/wetland to the southwest.

This project is feasible and very attractive, as few locations on campus offer the ability to manage significant volumes of runoff and impervious surfaces. Available surface area limits available treatment capability; however additional retrofit projects in the drainage area (i.e, B5a/b) may help reduce sizing requirements.

Figure 1. Drainage areas to proposed gravel wetland system include additional proposed retrofits.

Figure 2. Gravel based wetland system with underground chambers, pretreatment sediment forebay, and retaining wall.

Preliminary Concept Designs

A 25% concept design for the proposed retrofit can be found in attachment B, which includes preliminary plan views, cross sections, and project details (Figure 3). These initial plans will require field survey and more information on drainage pipes, utilities, and soils (among other things) before going to construction plans.

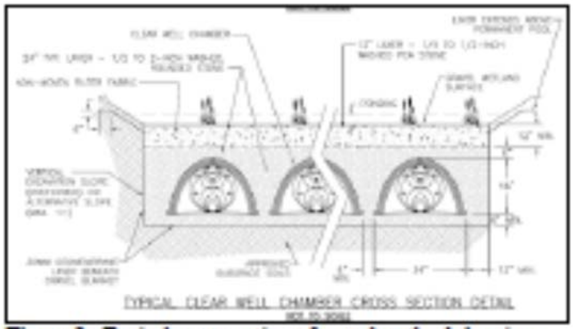

Figure 3. Typical cross section of gravel wetland showing underground storage chambers and vegetated surface where water pushed up from below is designed to pond.

Preliminary Hydrologic Calculations

Preliminary sizing of the gravel based wetland system was completed based on guidance provided in the *2009 Rhode Island Stormwater Manual (public review draft)* and are summarized in the table below.

Sizing calculations for Site B3	
Parameter	**Value**
Drainage Area, A (acres)	55.0
Imperviousness, I (%)	27
Volumetric Runoff Coefficient, Rv	0.30
Rainfall Depth, P (in)	
Water Quality Volume, WQv (cf)	59,345
Surface Area Required, Af (sq. ft)	8,386
Surface Area Provided (sq ft)	5,050
Treatment Provided (% of 1")	60

Design Considerations

- Sizing of facility is constrained by space and grade. Note the height of retaining wall, depth of forebay, and available head driving upflow filter. Sizing of facility can potentially be reduced if additional retrofits are installed within the drainage area upgradient.
- Must verify location of all existing storm drain infrastructure. Double check potential utility conflicts (i.e., sewerline).
- Final design to include cleanouts for gravel wetland and maintenance access for forebay.
- May need to relocate existing fence and install guardrail along road.

Maintenance

Maintenance will generally be related to landscaping practices and sediment removal from pretreatment forebay to prevent clogging. Inspect semi-annually for the first year of operation and annually after the first year as well as after major storm events. The routine maintenance activities typically associated with gravel-based wetlands are summarized in the table below.

Maintenance Activities	
Activity	**Schedule**
• Replant vegetation to original design standards if less than 50% of the original vegetation is established	After two years
• Remove and replace ill-established, dead, or severely diseased plants	Annual
• Inlets, outlets, and overflow spillway will be checked for blockage, structural integrity, and evidence of erosion • Sediment build up at the cleanout pipe will be removed	Routinely and after major storm events
• Clean and remove debris at cleanout pipe • Sub-surface storage chambers shall be flushed and/or snaked	As needed (if standing water is observed 48 hours after storm event)

Cost Considerations

$30/sf, not including utility/ main drainage pipe relocation.

Site B11: Parking Lot W

Managing Parking Lots with Bioretention

Project Summary

Parameter	B11a	B11b	B11c	B11d
Impervious Cover Treated (acres)	0.86	1.38	1.02	0.92
Runoff Reduction Volume (cu ft per 1" rain event)	1,553	1,864	1,932	1,916
TN Removal (lb/yr)	9.12	10.95	11.35	11.25
TP Removal (lb/yr)	1.06	1.27	1.32	1.31
TSS Removal (lb/yr)	229.3	275.4	285.5	283.1
Estimated Cost	$27k	$33k	$34k	$34k

Site Description

The proposed retrofit concepts are located in Parking Lot W in the northern portion of UConn campus near the reservoir and Greek Housing area. This large parking lot is showing signs of decay and is, reportedly, underused.

Existing Conditions

The upper northwest and eastern portions of the parking lot drain out of the watershed. The remaining portions of the lot (~ 6 acres) are divided into four separate catchments that drain to surface inlets. There are currently no stormwater practices treating the runoff. Soils at this site appear suitable for infiltration.

Proposed Concept

Concepts to use bioretention facilities to capture and treat runoff from the four drainage areas:

Area A: Block inlets and use curb cuts/sidewalk cross drains to direct runoff into forebay and bioretention area. Shape cell to avoid existing trees. Overflow to manage/treat drainage area of approximately 1 acre. Underdrain and outlet overflow back into existing stormdrain.

Area B: Remove pavement to install a 5 ft wide bioretention to manage/treat parking lot and upslope pervious area of approximately 2.6 acres. Restripe parking area, bioretention located in island between travel lanes as shown on sketch; no pretreatment, stone check dams.

Area C: Grass channel and/or forebay for pre-treatment flowing into bioretention along edge of lot. Convert existing inlet to manhole at low point, provide positive drainage to grass channel/forebay flowing into bioretention. Overflow via rip rap spillway back into existing drainage feature.

Area D: Block existing inlet and divert runoff to bioretention area via curb cuts/paved flume into forebay then into bioretention. Overflow ties back into existing drainage inlet. No underdrain required. May need to relocate existing electric lines.

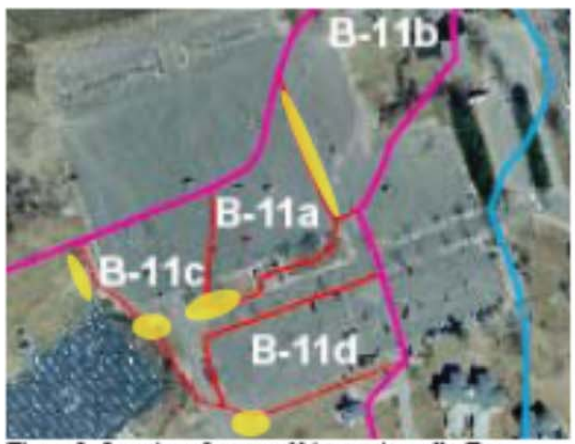

Figure 1. Location of proposed bioretention cells. Two portions of lot drain out of the Eagleville Brook watershed (outside of pink line).

Figure 2. Approximate location of proposed bioretention cells in parking lot. Restriping of lot will be required around landscape island bioretention to alter current traffic flow patterns. Loss of only four or five spaces anticipated.

Preliminary Concept Designs
25% concept designs for proposed retrofits can be found in attachment B, which includes preliminary plan views and project details. These initial plans will require field survey and more information on drainage pipes, utilities, and soils (among other things) before going to construction plans.

Preliminary Hydrologic Calculations
Preliminary sizing of the bioretention area was completed based on guidance provided in the *2004 Connecticut Stormwater Quality Manual*. These computations are summarized in the table below.

Sizing calculations for Site B11				
Parameter	Value			
	A	B	C	D
Drainage Area, A (acres)	0.98	2.57	1.38	1.09
Imperviousness, I (%)	88	54	74	84
Volumetric Runoff Coefficient, Rv	0.84	0.53	0.72	0.81
Rainfall Depth , P (in)	1	1	1	1
Water Quality Volume, WQv (cf)	2972	4962	3598	3193
Depth of the Filter Bed, d (ft)	2.50	2.50	2.50	2.50
Hydraulic Conductivity, k (ft/day)	1	1	1	1
Max. Ponding Depth, hmax (in)	9	9	9	9
Average Ponding Depth, h (ft)	0.375	0.375	0.375	0.375
Drawdown Time, t (days)	2	2	2	2
Surface Area Required, Af (sq. ft)	1292	2157	1564	1388
Surface Area Provided (sq ft)	1125	1350	1400	2200
Treatment Provided (% of 1")	87	63	90	100

Design Considerations

- Existing water lines and drainage pipes at site A to be verified in order to finalize location of inlet and determine if culvert under access road is required.
- Try to protect existing trees during excavation.
- At Site B, the only location for bioretention is island constructed between travel lanes, most runoff will enter in the upper portion, so provide forebay in first cell, may require check dams to terrace facility. Raise existing inlets to act as overflow.
- Design and excavation of bioretention and inlet structures at site C to save large tree.
- Feasible and likely cost effective, though site B is undersized given contributing watershed.
- No significant loss of parking spaces, though lot will need to be restriped.

Maintenance
Maintenance is important for bioretention areas, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. The routine maintenance activities typically associated with bioretention areas are summarized in the table below.

Maintenance Activities	
Activity Schedule	Frequency
• Water once a week during the first two months, and then as needed and depending on rainfall to promote plant growth and survival. • For the first six months following construction, the site should be inspected at least twice after storm events that exceed a half-inch. Inspectors should look for bare or eroding areas in the contributing drainage area or around the bioretention area, and make sure they are immediately stabilized with grass cover.	As Needed (following construction)
• Prune and weed bioretention area to maintain appearance. • Remove accumulated trash and debris.	Regularly (Monthly)
• Inspect inflow area for sediment accumulation and remove any accumulated sediment or debris. • Inspect bioretention area for dead or dying vegetation. Plant replacement vegetation as needed.	Annually
• Remove and replace existing mulch	Every 2 to 3 Years

Other Considerations

It was reported that a stormwater master plan has been proposed that will divert stormwater from this area to Swan Lake, and ultimately out of the watershed.

Site C4/5: Education/Gentry Buildings and Sundial Garden

Integrating Stormwater and Landscape Management

Project Summary

Parameter	C4/5-a	C4/5-d	C4/5-e
Impervious Cover Treated (acres)	0.12	0.07	0.34
Runoff Reduction Volume (cu ft per 1" rain event)	162	101	474
TN Removal (lb/yr)	1.42	0.89	4.17
TP Removal (lb/yr)	0.16	0.1	0.48
TSS Removal (lb/yr)	35.73	22.25	104.98
Estimated Cost	$11,000	$3,000	$13,000

Site Description

The proposed retrofit concept is located on the UConn Campus at the Education and Gentry Buildings. These two buildings are mirrored in design, and are separated by the Sundial Garden quad area.

Existing Conditions

The roof leaders from both buildings are directly connected to the stormdrain system. The adjacent green space in the Sundial Garden is highly compacted. Across the walkway in the student center quad, the soils are somewhat compacted. Several areas of localized soil erosion were noted.

Proposed Concept

Several retrofit opportunities were identified at each building (Figure 1). The locations of these projects are shown in attachment B:

- C4/5 (a) – Direct the front roof leaders into raised stormwater planter beds.
- C4/5 (b) – Direct the two downspouts near the main building entrances into cisterns. Water from the cistern can be used to water the building landscaping.
- C4/5 (c) – Amend the soils to restore the pervious area in the Sundial Garden and plant trees and a vegetative buffer along the southwest edge of the garden to reduce runoff and soil erosion.
- C4/5 (d) – Divert the two downspouts above the building side entrance into a bioretention area in the Sundial Garden. These bioretention areas can be incorporated into additional landscaping plans for this Garden.
- C4/5 (e) – Construct a large linear bioretention area along the walkway. Divert the walkway and terrace runoff into the area using berms or trench drains.

Figure 1. (C4/5-a) Potential location for stormwater planter boxes. (C4/5-b) Potential location for a cistern. (C4/5-c/d) Compaction in the Sundial Garden area and the proposed location of soil amendments and bioretention. (C4/5-e) Proposed location of larger bioretention project.

Preliminary Concept Designs

25% concept designs for the proposed retrofits can be found in attachments B. Preliminary plan views and project details are included. These initial plans will need to be further refined as this project proceeds towards construction.

Preliminary Hydrologic Calculations

Preliminary sizing of the bioretention areas was completed based on guidance provided in the *2004 Connecticut Stormwater Quality Manual*. These computations are summarized in the table below.

Sizing Calculations for Site C4 and C5			
Parameter	Value		
	C4/5-a*	C4/5-d*	C4/5-e
Drainage Area, A (acres)	0.12	0.07	0.47
Imperviousness, I (%)	100	100	72
Volumetric Runoff Coefficient, Rv	0.95	0.95	0.70
Rainfall Depth, P (in)	1	1	1
Water Quality Volume, WQv (cf)	403	251	1184
Depth of the Filter Bed, d (ft)	2.5	2.5	2.50
Hydraulic Conductivity, k (ft/day)	1	1	1
Max. Ponding Depth, hmax (in)	3	9	6
Average Ponding Depth, h (ft)	0.125	0.375	0.25
Drawdown Time, t (days)	1	2	2
Surface Area Required, Af (sq. ft)	384	113	538
Surface Area Provided (sq ft)	400	1000	1,215
Treatment Provided (% of 1")	100	100	100
*note, planters and sundial garden practices combined			

Design Considerations

- Site soils are compacted, so underdrains are needed in the bioretention and planter box designs.
- While utility constraints are expected to be minimal, detailed utility mapping should be obtained before completing the final project design.
- Construction of a new building being planned for a nearby site in the student center quad area may affect the project design for concept C4/5 (e). Therefore, the construction of project C4/5 (e) should not occur until after the new building is constructed.
- Projects (b) and (d) are good opportunities for student involvement and education. Students and faculty at Uconn can be involved in the final design and construction of this project.
- The Sasaki landscape architecture company has developed a landscaping plan for the Sundial Garden area. These plans can be incorporated with the proposed stormwater and soil amendment projects into a final design for this area.

Maintenance

Maintenance is important for bioretention areas, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. The routine maintenance activities typically associated with bioretention/planter boxes areas are summarized in the table below.

Maintenance Activities for site C4/C5	
Activity Schedule	Frequency
• Water once a week during the first two months, and then as needed and depending on rainfall to promote plant growth and survival. • For the first six months following construction, the site should be inspected at least twice after storm events that exceed a half-inch. Inspectors should look for bare or eroding areas, and make sure they are immediately stabilized.	As Needed (following construction)
• Prune and weed bioretention area to maintain appearance. • Remove accumulated trash/debris.	Regularly (Monthly)
• Inspect inflow area for sediment accumulation and remove any accumulated sediment or debris. • Inspect bioretention area for dead or dying vegetation. Plant replacement vegetation as needed.	Annually
• Remove and replace existing mulch.	Every 2 to 3 Years

APPENDIX C. Summary of LID Implementation to Date on UConn Campus.

Implementation of LID practices has been underway for several years on the UConn campus. In 2004, the first biroretention area on campus was installed near the Towers dorms (Figure 5). In 2005, several more bioretention areas were installed at the Burton-Shenkman facilty (Figure 6), and at Hilltop dorms (Figure 7). In August 2010, several large bioretention areas were installed at Northwoods apartments as part of a site renovation (Figure 8). Smaller rain gardens were also installed at each of the buildings at the Northwoods complex.

Installation of pervious pavement began in 2005 with a small patio using EcoStone® pavers at Lakeside apartments (Figure 9). Larger installations continued in 2009 with a pervious asphalt lot near Towers dorms (Figure 10), and a pervious concrete installation near the field house (Figure 11). In 2010, a portion of the access road to Northwoods apartments was paved with pervious asphalt (Figure 12).

In 2009, a green roof was installed on math science building Gant Plaza (Figure 13). Funding for this demonstration and research effort was obtained from CT DEP Section 319.

More information on all of these projects can be found on the TMDL project website at http://clear.uconn.edu/projects/tmdl/progress.htm.

Figure 5. Bioretention by Towers dorms.

Figure 6. Bioretention at Burton-Shenkman facility.

Figure 7. Bioretention by Hilltop dorms.

Figure 8. Bioretention at Northwoods apartments.

Figure 9. Pervious pavers at Lakeside Apartments.

Figure 10. Pervious asphalt near Towers dorms.

Figure 11. Pervious concrete in front of field house.

Figure 12. Pervious asphalt at Northwoods apartments.

Figure 13. Green roof on Gant Plaza.