A Case Study: Southbury Medical Facility and Low Impact Development

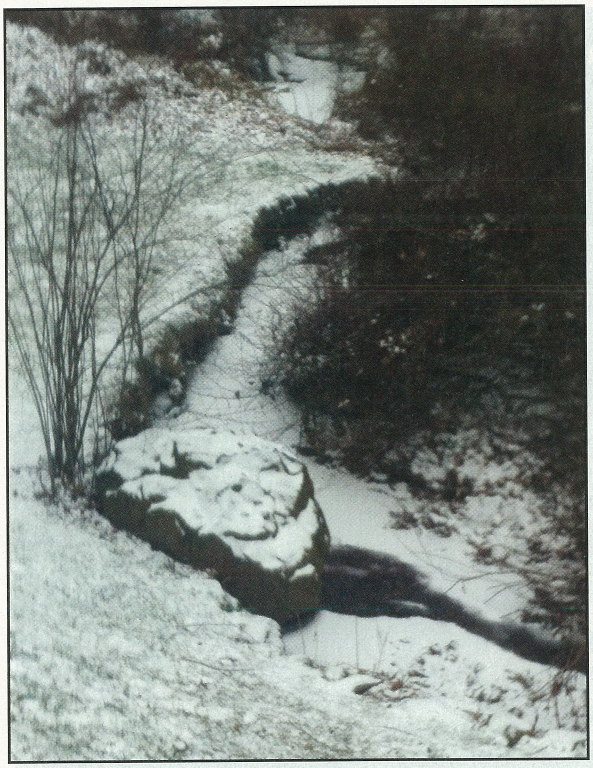
As the concept and acceptance of Low Impact Development (LID) strategies have been gaining traction in the land development field, it appears that many design professionals are having difficulty actually applying LID to actual projects. Many design professionals appear to think that LID is a one size fits all approach and therefore misapply and place LID treatment systems in inappropriate locations on a site. Some common examples of these issues are the belief that bioretention systems must be circular or elliptical in shape only or that they cannot be located on a slope. Another common issue is locating LID treatment systems at the end of the pipe instead of at source, which is one of the basic concepts of LID. These misconceptions result in LID systems, which fail soon after they are installed.

The hydrologic aspects of LID are a performance-based approach to addressing stormwater for typical land development projects. Hydrologic performance requirements must be achieved, but how they are achieved is up to the designer. The application of LID to land development projects requires a creative "out of the box" approach by the designer and not the same old way of doing things. When an 'out of the box" approach is taken by the designer to embrace the entire LID approach, the resultant site design will achieve the many goals of LID, such as preservation of natural resources, maintain pre-development hydrologic conditions for the small, frequent rainfall events as well as reducing pollutant loads found in stormwater.

Concrete stream channel located just south of the subject property and was channelized in the early 1970's.

In 2011, I had the opportunity to work on an environmentally sensitive site which the owner was requesting land use approvals for a medical office building and a prior application for this site was met with strong resistance from the local inland wetlands agency and resulted in the application being withdrawn by the applicant.

The site has several environmental constraints, the primary one being an extensive wetland/watercourse system, which traverses the site from the northeast to the southwest separating the undeveloped land from the existing commercial development. In addition, a second perennial watercourse is located to the east and south of the site. The southern portion of this watercourse is contained within a deep rectangular concrete channel with no biological component. In addition to the large wetland system, the watercourses on this site have been severely impacted by increased stormwater runoff volume from upgradient de-



Erosion of the stream channel bank at the southwest corner of the subject property.

velopment, which have minimal, if any stormwater detention systems. The result is that the streams are experiencing severe bank erosion and the resultant deposition of the eroded material in the downstream channel. Figure 1 shows the initial development concept which includes a bridge over the wetland/watercourse system, minimal buffers between the development and the wetland system, large extents of impervious, underground galleries with no pretreatment and standard dry detention facilities.

A primary concern in the design process was to prevent more adverse impacts to the wetlands and the watercourses as a result of this development. The proposed development consists of an office building for medical professionals containing approximately 40,000 square feet on three floors and approximately 155 parking spaces. It was clear that only with the implementation of LID strategies could this site be developed in an environmentally sound fashion and address the potential stormwater impacts. The revised plan, which eliminates any direct wetland impacts and provides substantial buffers to the wetlands from the development. It was proposed to locate LID treatment systems along the northern and western portions of the development within the buffer area adjacent to the delineated inland wetland area.

Erosion of the stream channel bank in the northeast corner of the site.

The design and long-term functionality of LID treatment systems, such as bioretention are highly dependent upon a comprehensive evaluation of the soils and groundwater conditions on a site. In this case, eight deep test holes were performed in the areas of the potential bioretention systems to observe the types of soil as well as indications of a seasonal high groundwater table (SHGL) or shallow bedrock. With the exception of one test pit, the soils in the area of the proposed bioretention systems consisted of deep well drained sandy loams, underlain by coarse sand and gravel. The shallowest evidence of a SHGL was observed at 4.5' below grade.

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Eight double ring infiltration tests were performed at an average depth of 36" below the existing ground surface to verify that the soils had a minimum infiltrative capacity of 0.5" per hour. The depth of these tests were based upon the fact that the bottom of the soil media in a bioretention system would be approximately 30" below existing grade and therefore the deeper soil layers would be required to infiltrate the runoff directed to the bioretention system. Infiltration rates ranged between 3 – 9" per hour in the sandy loam layer and 15 – 45" per hour in the sand and gravel layer.

The stormwater management plan had to achieve the following hydrologic performance requirements: Groundwater Recharge Volume (GRV), Water Quality Volume (WQV) and matching of the predevelopment peak rate of runoff for postdevelopment conditions for the twenty-five year rainfall event. The GRV is the required volume to match pre-development infiltration rate for a 1" rainfall event. The WQV is also based upon the 1" rainfall event and is the volume that must be "contained and treated" according to the 2004 CT DEP Storm Water Quality Manual to reduce post-development pollutant loads.

A key aspect of using LID treatment system is to avoid the concentration of runoff at a singular point. The most difficult aspect of implementing LID for this project was grading the site so that the entire parking area, including that area located to the south of the building would be directed as overland flow to the northern edge of the parking area. Another important aspect of LID is providing a pre-treatment system, which is easily accessible and maintainable. The pretreatment system should be designed to catch and hold coarse and fine sediments, similar to how a forebay works for a detention pond. By the trapping of sediment in a pretreatment system, maintenance of the primary treatment system is reduced significantly.

The site design uses bioswales located along the entire north and west limits of the parking area as the pretreatment system and bioretention systems without an underdrain to treat the runoff from all of the impervious areas of the development. As the elevation of the north edge of the parking facility slopes from the east to the west, the bioswales "step down the slope" by installing low weirs across the bioswale to maintain level sections between the weirs. The top of this weir is set 4" above the bottom of the bioswale.

The bioretention systems are connected to the bioswale by a short riprap channel and concrete weir. The height of this weir is 3" above the bottom of the bioswale. Both the bioswale and bioretention systems will use a soil media consisting of medium to sharp sand (85%), leaf compost (13%) and sandy loam (2%) with no more than 2% clay content.

The bioswales and bioretention systems will provide both groundwater recharge as well as reduction of pollutant loads found in non-point source runoff. The bioretention systems were made significantly larger than necessary in order to meet the peak rate attenuation requirement. It is generally not recommended to use a bioretention system as a detention system as the potential increased ponding depth and duration for a detention system

Infiltration Systems

There are several types of infiltration systems, which can be used where a more hardscape appearance is required. These infiltration systems consist of porous pavers, permeable pavement and porous concrete systems. While permeable pavement and porous concrete are not cost effective on small-scale applications, the various types of porous pavers are a very cost effective option to reduce impervious surfaces while infiltrating rainfall into the ground.

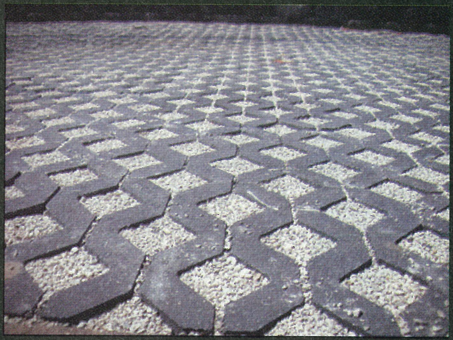

Figure 1 - Open pavers with gravel.

There are two basic types of porous paver systems. The first type of system consists of open paver systems, which are open block systems, which are set vertically on top of a permeable gravel base. The open holes can then be filled with pea gravel to give the appearance of a gravel driveway with the blocks providing the structural support for vehicles. The gravel remains un-compacted as the vehicle loads are carried by the block, thus rainfall falling on the driveway can infiltrate through the gravel and into the native underlying soils. An example of this type of paver is shown in Figure 1 above.

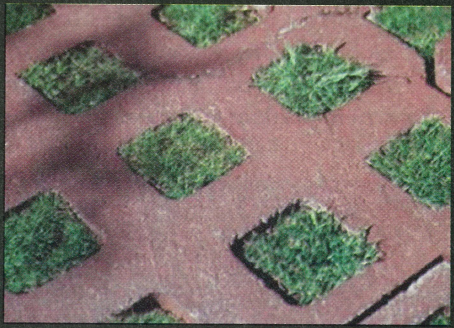

Figure 2 - Open pavers with grass.

The openings in the open pavers can also be filled with topsoil and then seeded to give a driveway the appearance of being all grass. It is very important when using topsoil in the pavers to have the top of the topsoil set below the top of the concrete paver so that the root system does not become compacted by the movement of vehicles over the surface. Figure 2 shows a proper way to construct this system.

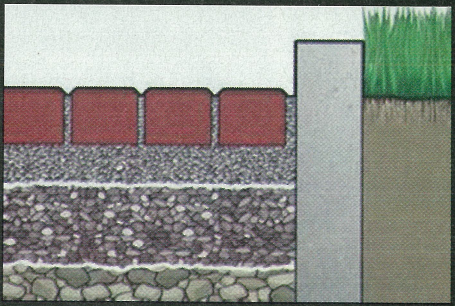

Figure 3 - Typical cross section of open paver systems.

The last type of paver system consists of solid paver stones with a porous material, such as coarse sand or very fine gravel placed between the stones to allow runoff to infiltrate in these gaps. Figure 3 below shows a typical cross section for this type of installation. These paver systems can be used for low traffic driveways, overflow parking areas, patios and walkways and also provide a functional and attractive surface.

will adversely affect the ability of the bioretention system to infiltrate runoff over time as the soil media surface can become clogged. In this case, the sizing of the bioretention systems were such that the ponding depth for peak rate attenuation did not exceed 12" which is commonly used as a maximum allowable ponding depth for bioretention systems.

The bioretention systems were modeled with Hydrocad software using an infiltration rate of only 25% of the slowest observed field infiltration rate to demonstrate that the post-development peak rate will be reduced to the pre-development peak rate. The Hydrocad analysis was done for each of the bioretention systems and showed that not only will small frequent storms fully infiltrate, but the post-development runoff from both the twenty-five year and fifty-year rainfall events will fully infiltrate into the ground with no surface discharge. By only using a fraction of the observed infiltration rate, a significant factor of safety is provided in the design which will ensure that the system functions properly even if the contractor does not completely follow the construction narrative.

It is also imperative to ensure that runoff from an impervious surface will always occur as overland flow to a bioswale or bioretention system to avoid potential concentrated flows which cause erosion issues in the treatment system. In this case, the soil surface of a short filter strip between the pavement edge and the bioswale is set a minimum of 2" below the elevation of the pavement. This creates a "drop edge" for the runoff to simply fall off and onto the filter strip. It also eliminates the buildup of sediment at the edge of the pavement and filter strip.

By the redesign of the project to protect the natural resources on the site and the implementation of LID strategies to address stormwater management, the project secured the necessary land use approvals from the Town of Southbury. It is important to note that while the hydrologic focus of LID is on small, frequent rainfall events, the design of the treatment systems can be modified to address both peak rate attenuation without adversely affecting the primary focus of groundwater recharge and pollutant reduction. **L&W**

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Learn More

If you like what you just read and are interested in learning more about low impact development, consider attending Steve Trinkaus' course "Low Impact Development - Solutions for Real Problems", at IECA's Environmental Connection 2014 (www.ieca.org). Set to take place in Nashville, Tennessee, February 25-28, it is the world's largest soil and water event. Steve's training course will introduce attendees to Low Impact Development, what it consists of, how to apply it to achieve maximum benefits and how to incorporate LID into municipal land use regulations.