A Natural Solution

AN INTRODUCTION TO LOW IMPACT DEVELOPMENT
FOR COMMERCIAL AND RESIDENTIAL APPLICATIONS
IN THE GRAND TRAVERSE REGION

Foreword

BENEFITS FOR DEVELOPERS AND PROPERTY OWNERS

Low Impact Development (LID) is a set of small-scale stormwater management practices implemented on a site that mimic and work with nature to reduce water runoff and pollutants. LID methods manage water and pollutants at the source, minimizing the impact of development on ground water, streams, rivers, lakes and coastal waters. The U.S. EPA has found that implementing LID practices saves substantial money for developers, property owners and entire communities, all while improving water quality.

Addressing pollutants with LID stormwater practices is of utmost importance in Grand Traverse region developments. In 1992 Grand Traverse County adopted a Storm Water Control ordinance. One of the primary objectives of the ordinance is to prevent accelerated soil erosion and sedimentation resulting from development. Excessive sediments from erosion – along with nutrients such as phosphorous from fertilizers – are the top two water quality threats to Grand Traverse Bay. In the rapidly growing Grand Traverse region, water quality is directly linked to economic vitality, high property values and a vibrant quality of life.

Implementing LID practices reduces project costs while improving environmental performance. Developers realize significant savings thanks to reduced costs for site grading and preparation, stormwater infrastructure and paving. Capital cost savings can range from 15% to 80% when implementing LID practices.

Benefits for developers include:

- Developing more units on a site. Less land is used for stormwater infrastructure, as compared to installing conventional ponds. This translates to having more land for additional lots, which increases profits.
- Increased property values based on desirability and proximity to open space. A real estate study conducted by American Lives, Inc., found that 78% of prospective homeowners rated natural open space as “very important” or “essential” in planned communities.
- Increased marketing potential.
- Faster sales. The aesthetic value of landscaping with trees, shrubs and flowering plants inherent in LID practices increases property values; this results in faster sales due to perceived value of “additional” landscaping.
- Higher property value. Location, location, location! Property owners are willing to pay premium prices to be located near aesthetically pleasing amenities such as open space, water features and gardens.

Benefits for property owners and communities include:

- Increased property values and higher property tax revenue.
- Enhanced aesthetics and improved habitat.
- Expanded amenities, public spaces and recreational opportunities.
- Reduced downstream flooding and subsequent property damage.
- A sense of public participation. LID practices implemented on individual lots increases awareness of local water quality issues.
- Higher overall quality of life.

Introduction

THE SMARTER PLAN

Welcome

In this book, you will learn more about an exciting new design strategy – the Low Impact Development (LID) approach – for managing stormwater runoff. Unlike other methods, LID mimics the natural and pre-existing site assets to minimize stormwater flow. Whether you are a planner, designer or homeowner, this guide will assist you in developing a stormwater management system that controls the quantity and quality of stormwater discharge.

During the past several years, developers, design engineers and regulators have successfully promoted LID stormwater techniques in the Grand Traverse region. This guidebook is intended to accelerate that progress and to foster LID as the norm rather than the exception.

Past Stormwater Management Methods

Traditional stormwater management and drainage design relied on piping stormwater from impervious surfaces (e.g., roofs and parking lots) to drainage pipes that flow to retention ponds and surface waters. The goal of such plans was to collect stormwater in discrete systems and carry it from the site as quickly as possible. If detention ponds were incorporated in the drainage plan, the basin was located away from the public.

These methods did not factor in the cumulative impact of previous modifications to a watershed, which can impact both the volume and rate of stormwater runoff. This result was extensive erosion and stream channel degradation. Further, these traditional storm basins were generally eyesores devoid of plantings that were difficult to maintain.

Modern, Effective and Natural: LID

The LID approach to stormwater management is modeled after nature itself: Rainfall is managed using controls distributed throughout the site. Instead of conveying and treating stormwater in large, costly, end-of-pipe facilities located at the bottom of drainage areas, LID addresses stormwater with small, cost-effective landscape features located at the lot level. These landscape features, known as Integrated Management Practices, are the building blocks of LID. Almost all development components can serve as IMP's: open spaces, rooftops, streetscapes, parking lots, sidewalks and medians. LID is a versatile approach that can be applied equally well to new developments, urban retrofits, and redevelopment or revitalization projects. It is important to note, however, that LID may not be suitable for certain urban brownfield redevelopment projects, as some practices may cause contamination of local ground water sources.

Traditional drainage plan

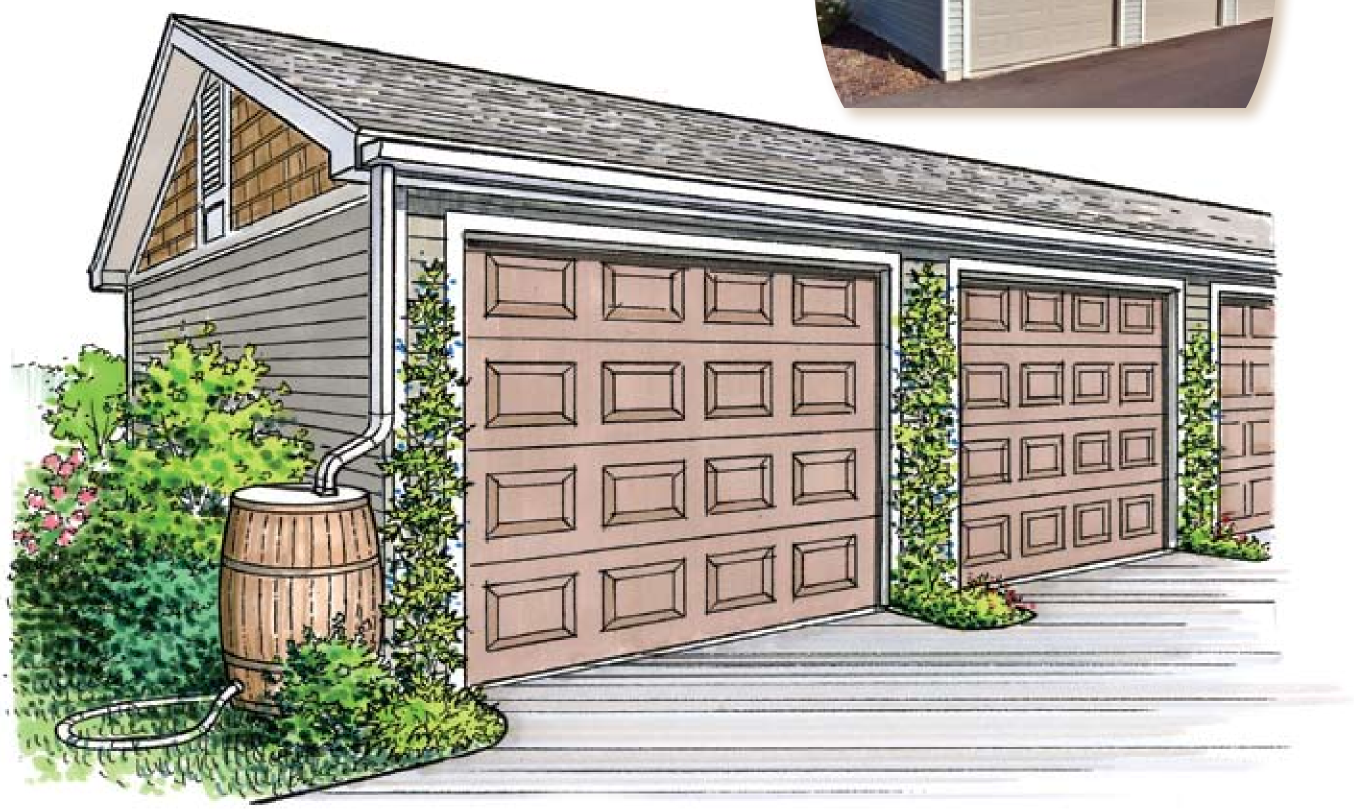
A LID approach to stormwater management requires reviewing existing conditions – especially vegetation patterns, soil types, slopes, and existing hydrologic features, such as streams, wetlands and open water areas. When natural areas are mapped, site planning and design should protect the natural features that influence the way water moves on the site. This includes streams, wetlands, drainage swales, wooded areas and soils with high filtering potential.

LID allows for greater development potential with fewer environmental impacts by using smarter designs and advanced technologies that achieve a better balance between conservation, growth, ecosystem protection, public health and quality of life.

Every site is part of an overall watershed and a visual setting, and the system should be designed with this in mind. The pre-existing drainage system for a site, as well as downstream conditions, should be reviewed to customize the stormwater management system. The system should conform to natural drainage patterns both on- and off-site. In particular, design guidelines for the Grand Traverse region – including local, state and federal standards – are an important starting point and reflect minimum performance standards. The stickers discussed in the Application Case Studies section (page 17) are useful for developers, planners, designers, regulators, and others to design stormwater solutions that maximize LID Integrated Management Practices.

Water Runoff

IMP's can be as simple as draining small amounts of parking lot and rooftop runoff to planting areas, which are landscaped to soften and enhance the appearance of a long expanse of garages and asphalt.

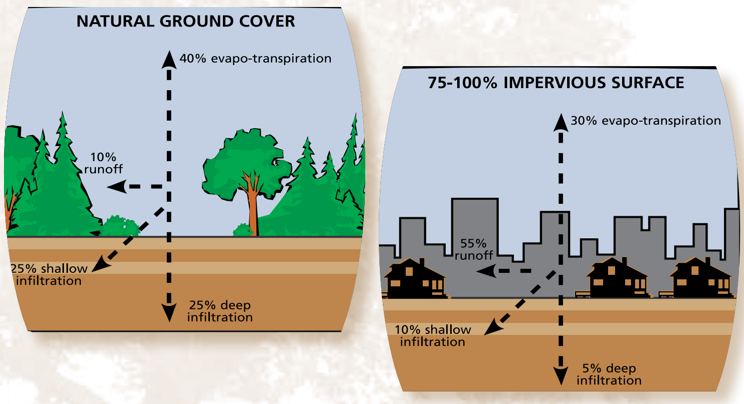


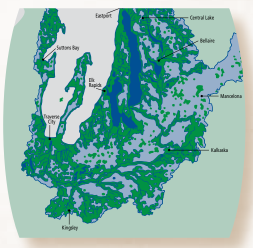
Planning

LID'S ROLE IN WATERSHED PLANNING

The top two pollutants to the Grand Traverse Bay watershed are excessive nutrients and sediment. These and other pollutants – oils, grease, gas, pesticides and lawn fertilizers laden with phosphorus – are largely carried to the Bay by stormwater runoff from rain or melting snow that is not absorbed into the ground. Urban locations typically have greater problems with stormwater runoff because they have more impervious or nonporous surfaces, such as pavement. LID plays an integral part in the management of stormwater runoff, an issue of greater concern as the Grand Traverse area becomes more developed.

Stormwater runoff





What is a watershed?

A watershed is an area of land that drains into a common body of water. When it rains or snow melts, there are many paths the water can take. It can soak into the soil and become ground water. Or it can enter a storm drain and then flow to a stream, lake or river – or in our case, to Grand Traverse Bay.

Watershed Protection Plan

In 2005, The Watershed Center produced the Grand Traverse Bay Watershed Protection Plan. The plan outlines current water quality conditions in the Bay and identifies current pollutant threats to water quality. Efforts to address these pollutants were researched, developed and prioritized. The plan contains an extensive list, organized into more than 15 categories, of potential tasks and projects to reduce pollutants. The plan also outlines a set of measurable milestones and criteria to evaluate the effectiveness of implementation efforts.

Success

MANY BENEFIT IN MANY WAYS FROM LID

One of the Primary Benefits of LID is its Flexibility

Working at a small scale allows volume and water quality control to be tailored to specific site characteristics. Almost every site and every building can apply some level of LID and Integrated Management Practices to improve water quality. The Grand Traverse Bay Watershed Protection Plan encourages incorporating LID to protect our region's water quality and distinct environment. Many of The Watershed Center's projects utilize LID, and we continually advocate for its use throughout the watershed.

Small-scale LID practice (rain garden) at Hull Park in Traverse City

Environmental, Property Owner, and Community Benefits

Water Quality: LID can improve local water quality by using vegetation to filter pollutants, reduce sedimentation (erosion), recharge groundwater, and reduce water temperatures.

Pollutant Filtering: Soil and plant-based filtration devices remove pollutants such as sediments, excess nutrients, heavy metals, plus oils and grease. Reducing pollutants to receiving waters is vital to protecting our exceptional regional water quality.

Reduced Erosion: LID reduces problems with high flow levels and on-site erosion caused by stormwater runoff.

Ground Water Recharge: The rate of ground water recharge is increased by keeping stormwater on-site and allowing it to absorb naturally into the ground.

Thermal Pollution: Water warms when it runs over land, which compromises the quality of our region's cold waters. Less overland flow to streams reduces the aquatic habitat stress of thermal pollution for coldwater species such as Lake Trout.

Flood Control – Runoff Volume and Timing: By infiltrating and temporarily storing runoff water, LID designs can reduce a site's overall runoff volume and maintain the predevelopment peak discharge rate and timing. This helps alleviate flooding problems.

Habitat and Aesthetics: LID provides attractive landscaping and natural habitat for birds, butterflies and other wildlife. Landscaping and other habitat features also offer quality of life opportunities by greening neighborhoods, enhancing the appearance of communities, contributing to livability, increasing value, and building a stronger identity of place.

Open Space: LID projects provide functional use of open space land.

Reusable Water for Irrigation: Using stormwater for irrigation reduces wasting clean, processed water from treatment plants for lawn watering. This also reduces water bill costs.

Economical Community Benefits: This includes increased property values, enhanced redevelopment potential, greater marketability, energy savings and smog reduction.



Developer Benefits

By emphasizing natural processes, LID is often less costly and more attractive than conventional stormwater controls. LID can reduce development and maintenance costs and create added value to a project. LID creates a desirable product that often sells faster and at a higher price than conventional developments.

Benefits for developers include:

- Reduced costs for site grading and preparation (less clearing and grading)
- Savings on infrastructure and paving (fewer inlets/curbs and lower asphalt costs)
- Reduced or eliminated need for stormwater ponds and other conventional methods (no pipes, pond liners, etc.)
- Less expensive to construct and maintain, plus longer life cycles than centralized stormwater systems
- Less land is used, as compared to installing conventional ponds, resulting in more available space for development
- Property values are optimized based on desirability and proximity to open space.
- Faster sales/higher value due to perceived value of "additional" landscaping and proximity to open space, water features and gardens
- Capital cost savings can range from 15% to 80% when implementing LID practices

LOW IMPACT DEVELOPMENT IN SITE PLANNING AND DESIGN

LID is as much about site planning and design as it is engineering practices. Projects that consider LID approaches at the outset are more effective than those that add best management practices following the development process. The following techniques are suitable for the Grand Traverse region.

Conservation Site Plan

A conservation site plan preserves open space and natural features, plus minimizes developed areas. Many communities refer to conservation site plans as planned unit developments. These types of projects cluster development with higher density to protect natural or hydrologic features. In a conservation site plan, development is higher density, and the land that is set aside provides some sort of hydrological function that mitigates the impact of stormwater. The conserved open space also serves as a desirable feature for property owners.

Left: Conventional Site / Right: Conservation Site

Case Example:

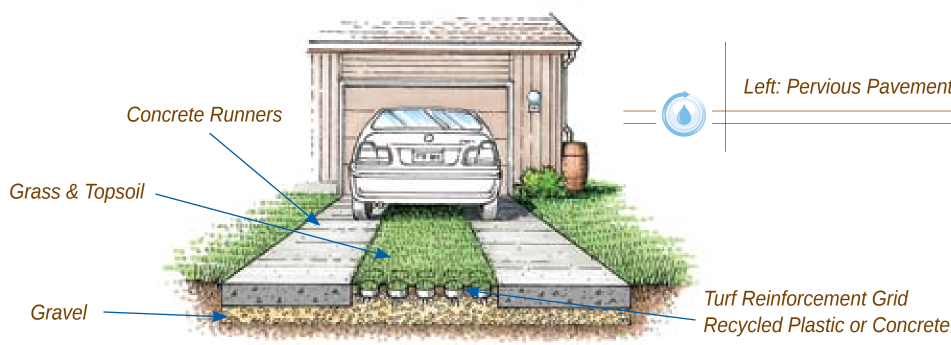
Suppose a 120-acre parcel of land is zoned for single family development with 12 10-acre lots. With a conservation site plan, 27 home sites would be concentrated on 49 acres of land, and the remaining 71 acres would integrate infiltration basins, bioretention swales, constructed wetlands and other LID practices. This would preserve woodlands, wetlands and sloping terrain.

Minimize Impervious Surfaces

Reducing impervious surface area, whether in a conventional or conservation site plan, is an effective technique to mitigate stormwater impacts. One common technique is narrowing the width of roadways in residential developments. The reduced pavement area in turn reduces the volume of runoff discharged from a site. When a project involves commercial or retail development, a common approach to minimize pavement is to land-bank parking; this leaves an area banked in native vegetation for future use as overflow parking.

Left: Conventional Site / Below: Conservation Site

It is important to distinguish between reducing impervious areas and pervious pavement. Both techniques have a place in LID, but reducing impervious areas results in preserved open space. Pervious pavement, on the other hand, reduces stormwater runoff volume, but does not necessarily preserve open space. Of course, using both practices is highly effective.

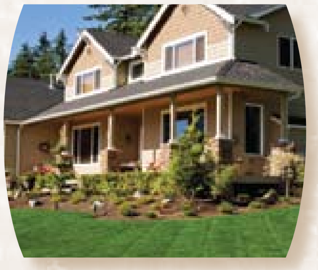


Left: Pervious Pavement

Source Control

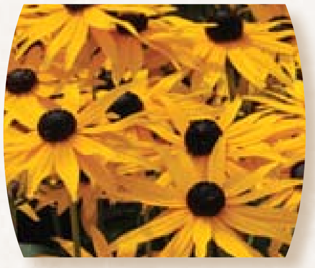
One of the effective measures to control nutrient and sediment runoff is to control the source of these pollutants. Parking lot and street sweeping has been shown to reduce sediment and nutrient concentrations in runoff by 5% to 20% depending on the frequency. Sweeping pervious pavement is important to maintain its pervious nature, and it is also an effective source control that collects sediment from the parking lot before it is rinsed into the stormwater system.

Nutrient runoff can also be effectively managed through source control. Source control of nutrients can be achieved by regulating the quantity and type of fertilizer applied. Always check the nutrient levels of soil before applying fertilizer. Oftentimes soil nutrients are adequate to provide healthy turf. When a soil analysis indicates low levels of a particular nutrient, select a fertilizer that supplies the nutrient in the amount required by the plant. Overfertilizing is not recommended; the excess fertilizer that is not used by the plants will be washed into lakes and streams near the development.



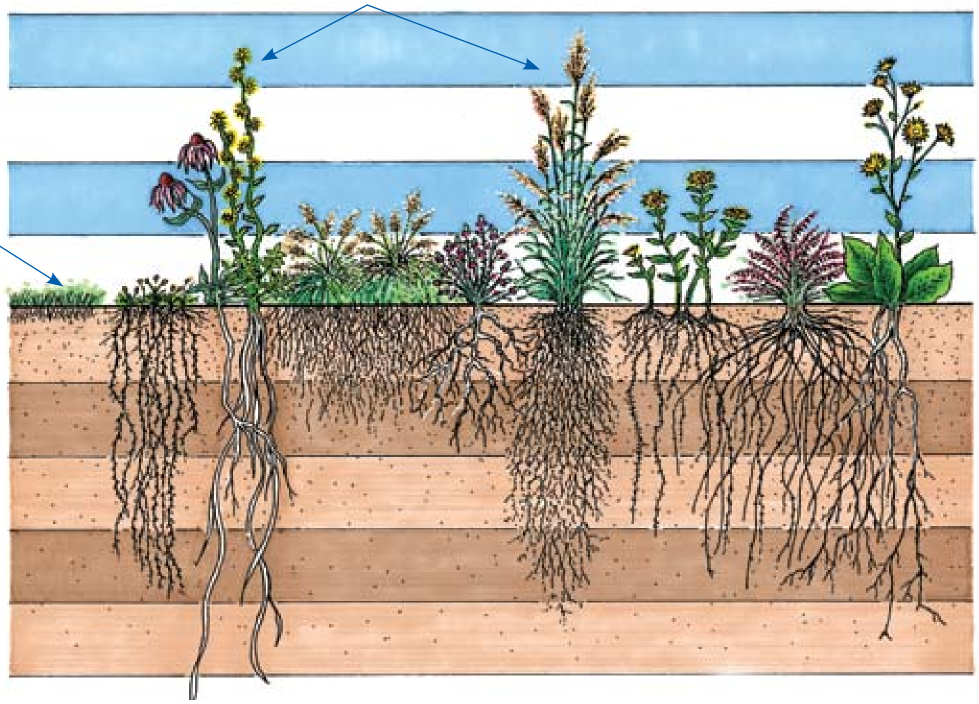
Another aspect of controlling the source of nutrients is to select a slow-release fertilizer that matches the chemical needs of plants. Slow-release fertilizers are especially important in the Grand Traverse region because the nutrient-binding properties of sandy soils are low. As a result, if a fertilizer is not slow-release, it may be lost from the soil and carried to nearby lakes and streams.

Finally, source control of nutrients can be achieved by using native plants that can survive without fertilizers. Consider minimizing turf areas that require fertilizer and herbicides to be productive. If turf is desired, consider a variety that is low maintenance and requires less fertilizer and water to thrive in northern Michigan, such as Creeping Red Fescue.



Preserve Natural Vegetation

As mentioned earlier, preserving natural areas is an important part of LID. Studies show that natural vegetation areas intercept and store more water than manicured landscapes. By preserving natural vegetation designs, the water flow pattern is preserved and the need to install engineered stormwater systems is reduced. In addition to the hydrologic benefits of natural vegetation, nutrient levels are significantly lower than those from manicured lawns and landscapes.



Comparative Root Systems of Native Plants and Turf Grass

The extensive root systems of native plants are more effective at filtering pollutants and preventing erosion than the root systems of turf grass.

Preserve Existing Drainage Paths and Streams

Preserving and incorporating natural drainage patterns in the final design is an important characteristic of LID developments. By preserving natural swales and small streams, nutrient migration is reduced as compared to conventional developments. Streams and swales that should be prewserved may not have flowing water year-round, but they trap nutrients and sediment from rainfall and melting snow.

Utilize Low Impact Landscaping

Consider long-term maintenance of vegetation when installing landscaping features to reduce labor, watering and chemicals needed. By properly preparing soils and planting native species adapted to a site's climate, plant establishment improves, which in turn stabilizes soils to better filter pollutants.

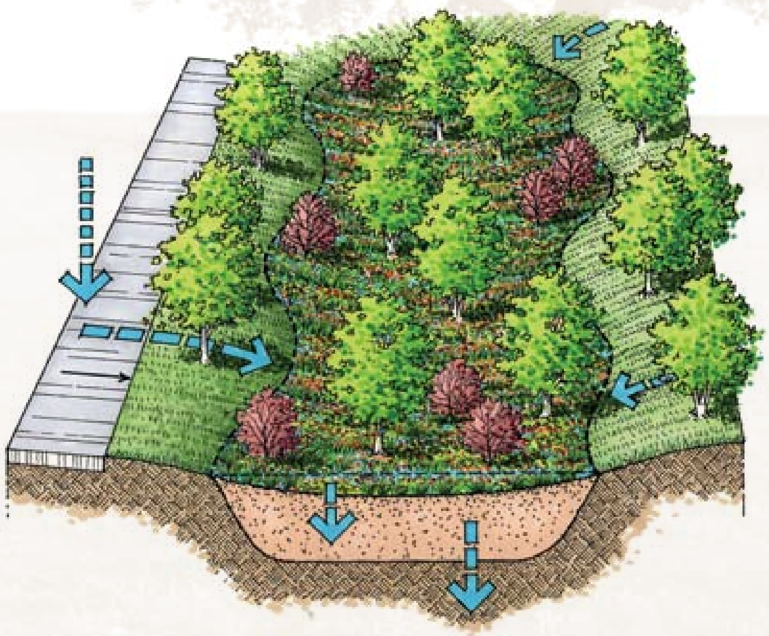
LID TECHNIQUES – INTEGRATED MANAGEMENT PRACTICES

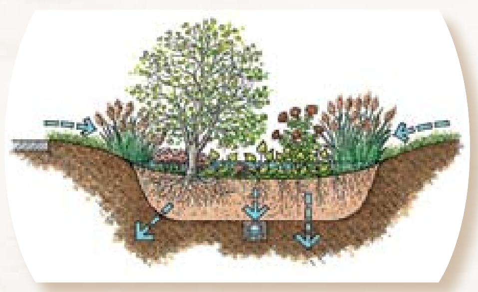
In addition to the site planning and design strategies previously described, there are numerous engineering practices that can be utilized in a LID program. The following is an introduction to practices most commonly associated with LID projects.

Bioretention and Biodetention Basins

Bioretention and biodetention areas are shallow depressions with suitable natural soils and vegetation that retain, treat and filter water. Sometimes the basins are constructed by replacing unsuitable soil with soil designed to allow more infiltration to the ground water system. These basins are designed to hold water to a maximum depth of 6 to 12 inches, the effective depth for vegetation to remove sediment and nutrients. Biodetention basins have an outlet for release to surface water; bioretention basins have no such outlet and hold runoff.

The most important distinction between these basins and conventional basins is that they mimic the natural hydrologic cycle by holding runoff long enough to allow nutrient and sediment removal, filtration and evaporation. These systems can also provide wildlife habitat, which increases interest and acceptance, especially in residential projects. Bioretention and biodetention basins may not be appropriate for significant quantities of sediment and nutrients that will overload them. In such situations, some type of source control (e.g., streetsweeping) should be incorporated to ensure effectiveness.

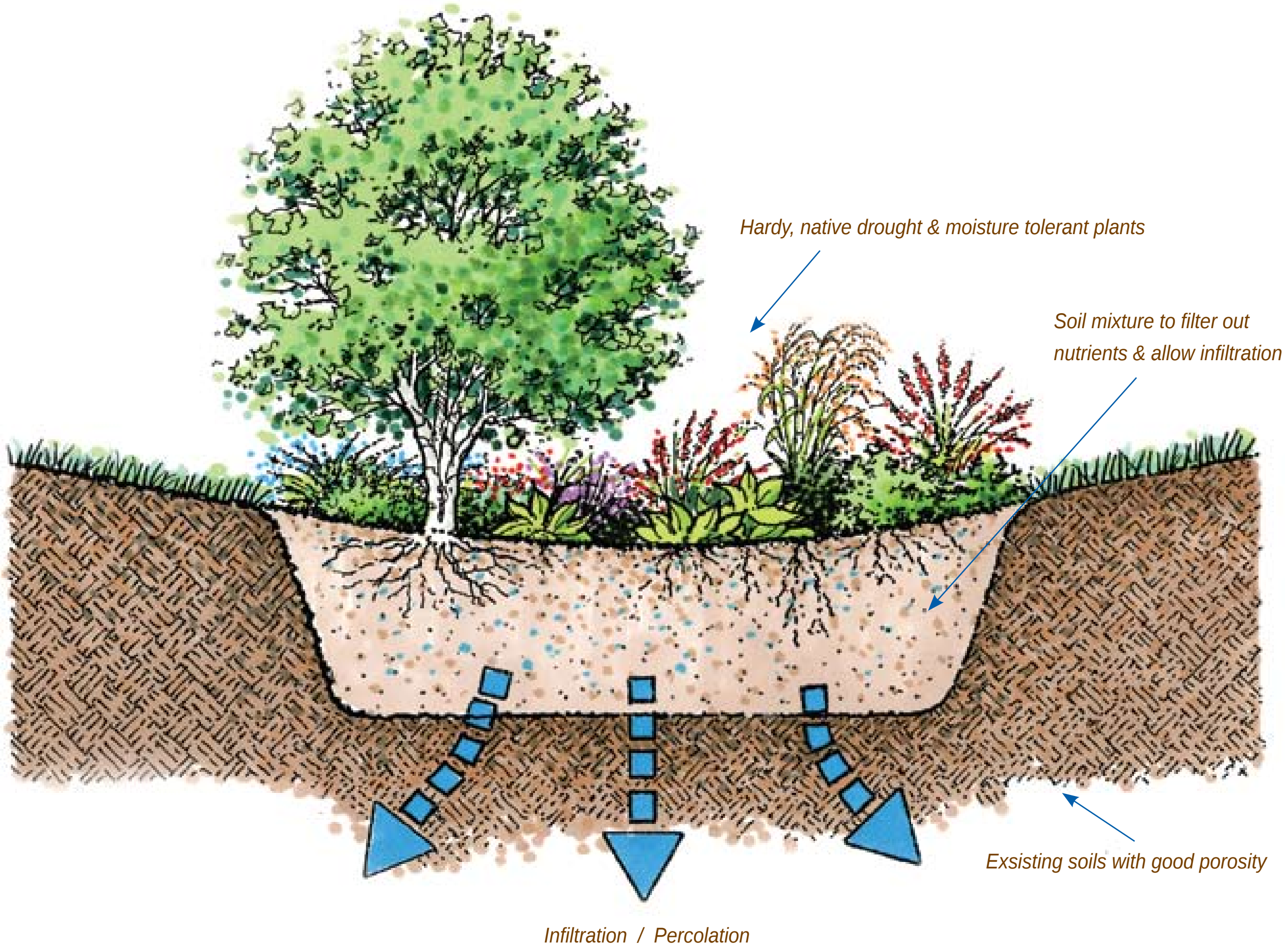


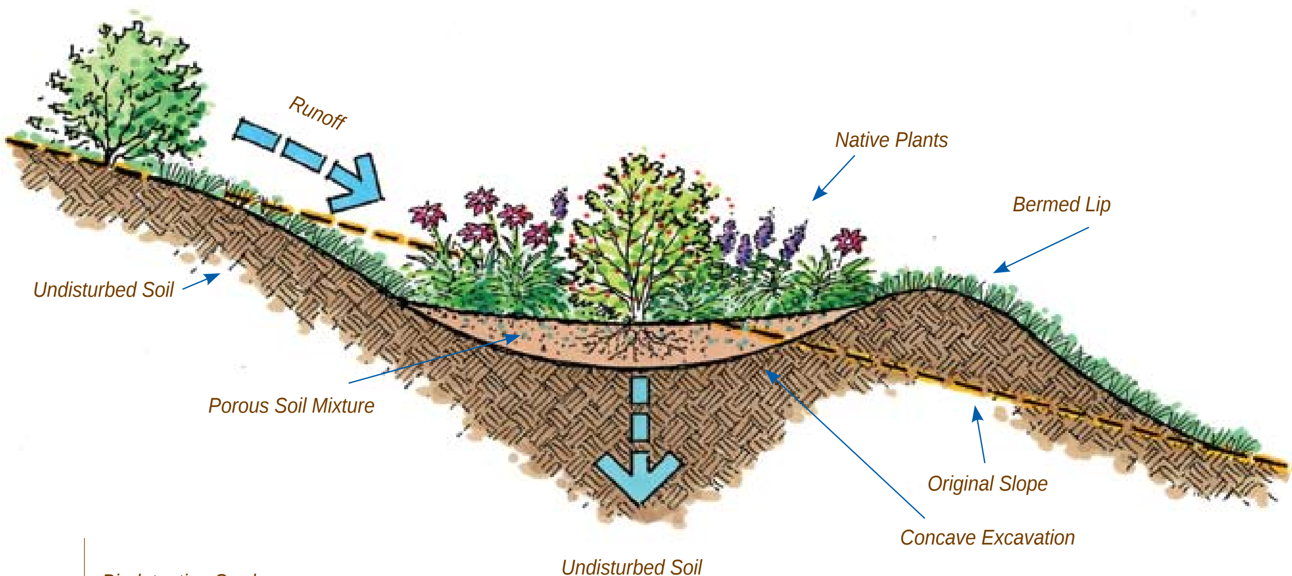


Biodetention Basins

Biodetention Swales

Biodetention swales are conveyance systems that can complement bioretention or biodetention basins. These shallow vegetated swales are designed with a very flat slope, usually less than 0.5%, to increase retention time; this maximizes filtration and percolation. Unlike conventional conveyance systems, water and nutrients percolate into the ground prior to reaching the bioretention basin. In many cases, it is important to manage sediment quantity flowing into the swale to prolong its life. *(See images, right.)*


Hardy, native drought & moisture tolerant plants
Soil mixture to filter out nutrients & allow infiltration
Exsisting soils with good porosity
Infiltration / Percolation


Runoff
Native Plants
Bermed Lip
Undisturbed Soil
Porous Soil Mixture
Original Slope
Concave Excavation
Undisturbed Soil

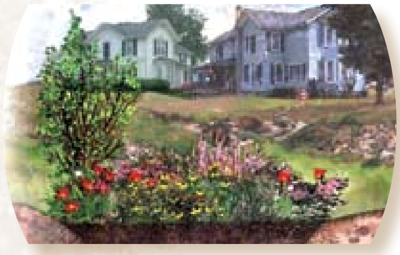
Water Quality Swales

Water quality swales are similar to biodetention swales, with the exception that they minimize retention and filtration, but maximize sediment and nutrient uptake by soil and vegetation. The swales are frequently constructed on or lined with impermeable soil to minimize infiltration to the ground. The swales are generally flat with broad areas for vegetation to become established, optimizing sediment filtration and nutrient uptake. The swales can be designed for wetland vegetation or upland vegetation; however, if the swale receives frequent runoff, it will be difficult to establish upland vegetation. These swales are ideal for situations where sediment and nutrient load is expected to be heavy and where ground water recharge is not desired.

Water Quality Swale – Photo Courtesy of Don Tilton

Rain Gardens

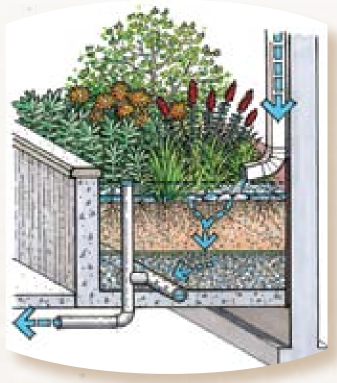
Rain gardens are bioretention basins designed on a residential scale and planted with flowering perennials to blend into a residential landscape. The rain garden is located where runoff can be directed into it without threatening building foundations. The rain garden is a shallow depression planted with perennial species native to the Grand Traverse region that tolerate wet soils. Shredded mulch is used to optimize water storage and to control weeds. Rain gardens are ideal residential tools, but they are not suitable in situations with heavy sediment load.

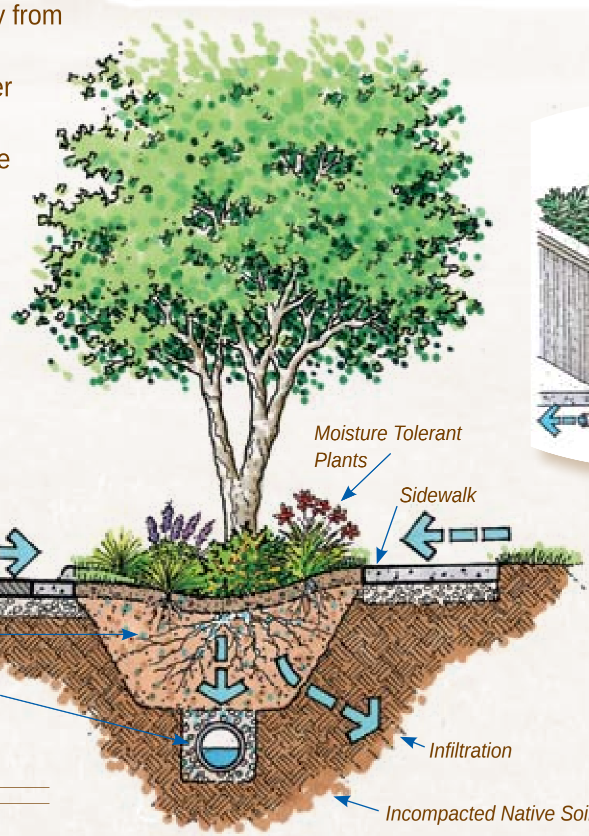


Rain Garden – Photo courtesy of www.raingardens.org

Flow-Through Planters

Flow-through planters are structures or containers with impervious bottoms. They are filled with gravel, soil and herbaceous plants or trees. Stormwater flows to the planters, usually from roof tops, and is stored in the planter, with some applications designed for sidewalks. Excess water is collected and drained to a collection system. Flow-through planters reduce runoff rates, volume and water temperature. Depending on the soil mixture and type of vegetation used, they can also remove nutrients. These systems are ideal for applications adjacent to buildings or retrofits in urban settings. The planters can be designed in many different shapes and sizes.



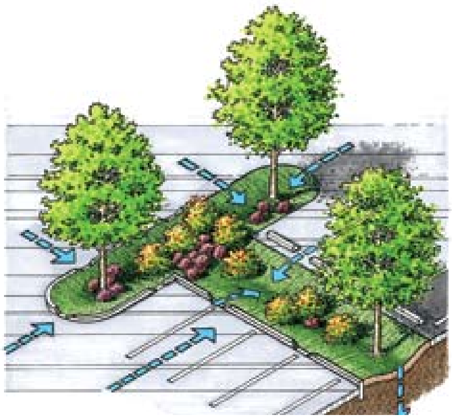


Flow-Through Planter and Street Tree Plantings

Infiltration Systems

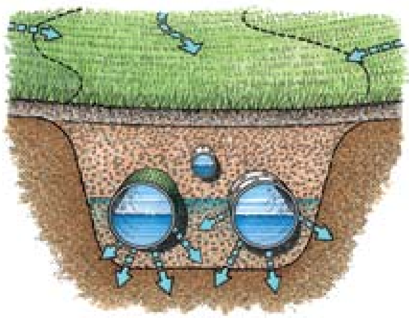
Infiltration systems are volume-management systems that encourage downward movement of runoff into soil. Techniques include trenches, drain fields, basins and dry wells. Trenches, dry wells and basins are most suitable for the climate and geology of the Grand Traverse region. Infiltration systems are extremely effective in recharging ground water and controlling runoff volume, but they can become clogged if excessive sediments are discharged into them. They are ideal for the final stage of a stormwater management system after sediment has been removed.

Infiltration systems differ from bioretention and biodetention systems in that nutrient removal and wildlife function are reduced. The primary use for this tool is recharging ground water and reducing runoff volume. Infiltration systems also protect cold water stream habitat; warm runoff is directed to ground water, where it is cooled.



Infiltration Parking Island

1) **Infiltration Trenches** are excavated and backfilled with an aggregate material to increase filtration. In some areas of the Grand Traverse region, the native soil material provides the correct permeability characteristics, and gravel is unnecessary. Infiltration trenches are most effective for rooftop runoff where sediment load is very low. They can also be used for parking lot runoff, but it is important to control the sediment load from the parking lot so that the infiltration trench does not clog. In certain situations, infiltration trenches incorporate a drainage pipe at the bottom to increase water movement and drainage.



Infiltration Trench

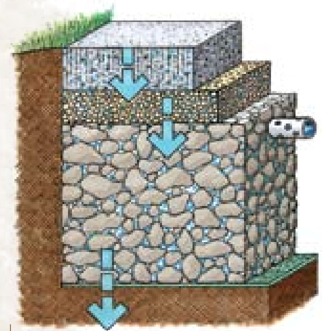
2) **Infiltration Basins** are a variation of an infiltration system that collects water in a basin prior to absorption into the ground. In the Grand Traverse region and many surrounding areas, the soil composition is such that infiltration basins can be built without adding gravel or drainage systems. Infiltration basins are rarely designed to handle large storms; therefore, they tend to be smaller and can be placed in tight spots. They are frequently used in urban retrofits. A common problem with infiltration basins is the undesirable appearance of the vegetation. Low-maintenance plants and seed mixes should be selected for sandy soils.

Infiltration Basin – Photo Courtesy of Don Tilton

Porous and Permeable Pavement

Porous pavement is a permeable pavement, either asphalt or concrete, that allows water to permeate the pavement and recharge ground water. Porous pavement appears similar to impervious pavement, but the manufacturing process omits fine particles, which creates larger voids. Runoff is collected in the stone sub-base or allowed to drain directly into the subsoil. Porous pavement has been used in several different applications in Michigan, including downtown Traverse City (see photo). Porous pavement reduces runoff volume, rate and warming. Porous pavements should not be used in areas likely to generate highly contaminated runoff, with impermeable subsoils, or close to drinking water supplies.

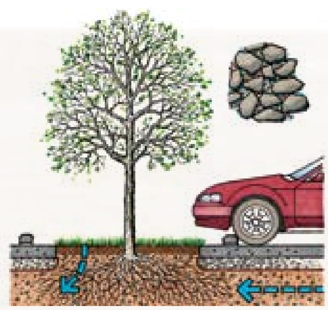
Porous/permeable Pavement site in Downtown Traverse City



Porous/permeable Pavement

Structural Soils

Structural soil is a rooting medium compatible with pavement design in urban settings that allows tree roots to penetrate the material. Tree planting in urban settings is a valuable tool to mitigate heat island impacts and contaminated runoff. However, tree planting and growth in urban areas is constrained by the amount and quality of soil. Structural soil provides a firm base for pavement design that allows root growth and filters stormwater runoff.



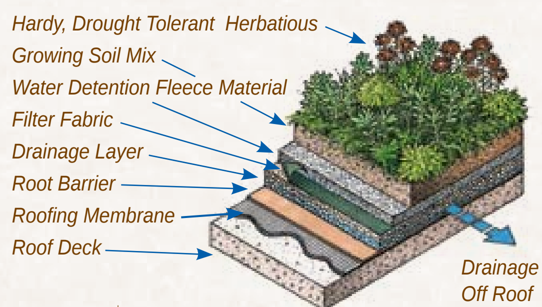
Structural Soils

Green Roofs

A green roof is a building roof that is partially or completely covered by vegetation and soil placed on a waterproof membrane. Green roofs reduce building heating loads, urban heat island effects and stormwater runoff. Green roofs can be as simple as small roof gardens, or they can be extensive vegetated systems spanning the entire roof. Notable examples of green roofs in Michigan are the Ford Motor Company manufacturing facility in Dearborn, the offices of West Michigan Environmental Action Council in Grand Rapids, and the Grand Rapids Hospital.

Some disadvantages of green roofs include initial construction costs to reinforce the structure, maintenance costs if the roof leaks or becomes damaged, and insurance costs. These systems are best for intensive urban settings, but should be carefully analyzed when alternative LID approaches may be just as practical.

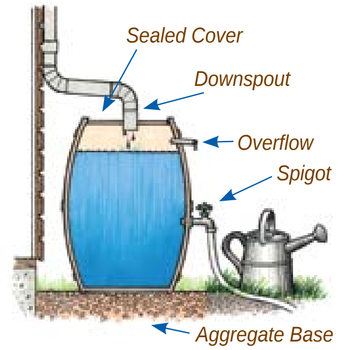
Green Roof at West Michigan Environmental Action Council Building



Green Roof Section

Water Harvesting and Reuse

The Grand Traverse region is not considered a dry environment, but there are advantages to designing a stormwater system that stores surplus runoff generated in the fall, winter and spring for various uses. The most common reuse is as irrigation water, but some engineers have implemented systems to use stormwater for cooling systems, water supply for buildings, or as water supply for fountains and ponds onsite. Water harvest systems reduce runoff volume and rate, nutrient discharge, and thermal pollution. They also save money compared to using municipal water sources for irrigation. Water harvest systems can be designed using retention ponds or constructed wetlands, or they can be fairly simple rain barrels suitable for residential settings. Rain barrels are attached to downspouts and collect rain water. The water is then used during dry periods for watering flowers, trees and other landscape plants.



Rain Barrel

Underground Storage

Storing stormwater runoff underground has been used more frequently during the last few years. The process consists of storing runoff in chambers located under parking lots, tennis courts, or other land uses for recharging to ground water or discharging to a storm sewer system at a controlled rate. These systems are most appropriate when infiltration basins or biodetention basins are not suitable. They are typically used in urban settings or on properties where land area for stormwater management is restricted. Their main benefit is managing stormwater volume and discharge rate; but if a design is selected that allows filtration, then ground water recharge can be an added feature. In some systems, underground storage is used with water reuse management systems. There are a variety of systems, including concrete vaults, pipes of various materials, and half pipes. All of the systems provide various advantages and disadvantages, so selecting a particular system should be done after careful study.

Underground Storage Illustration courtesy of www.stormtech.com

Considerations

INITIAL OVERSIGHT AND LONG–TERM PLANNING

Given that LID concepts are new, contractors will undoubtedly need more oversight from engineers. In certain installments, contractors have changed LID systems on-site, as oftentimes LID practices are the exact opposite of conventional designs that they are familiar with. This increased oversight, of course, may result in higher engineering costs to properly oversee contractors and to inspect projects. This may be the case until LID systems become commonplace.

For example, contractors need to understand that driving heavy equipment through a rain garden compacts the soil, thereby compromising its effectiveness. Or that parking lot grading must spread out sheet flow to make use of all bioretention areas.

It is important to bring the project team together before embarking on the construction process. This communication is vital, as LID designs can vary greatly from traditional designs.

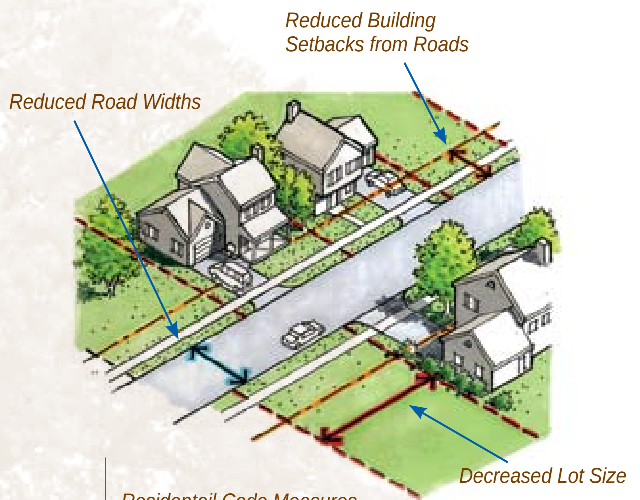
Also, property owners need to be educated to plan for ongoing maintenance costs for specific LID practices. For example, rain gardens require regular maintenance, including watering plants to properly establish them, weeding and removing debris.

Actions

PUTTING YOUR PLAN TO WORK

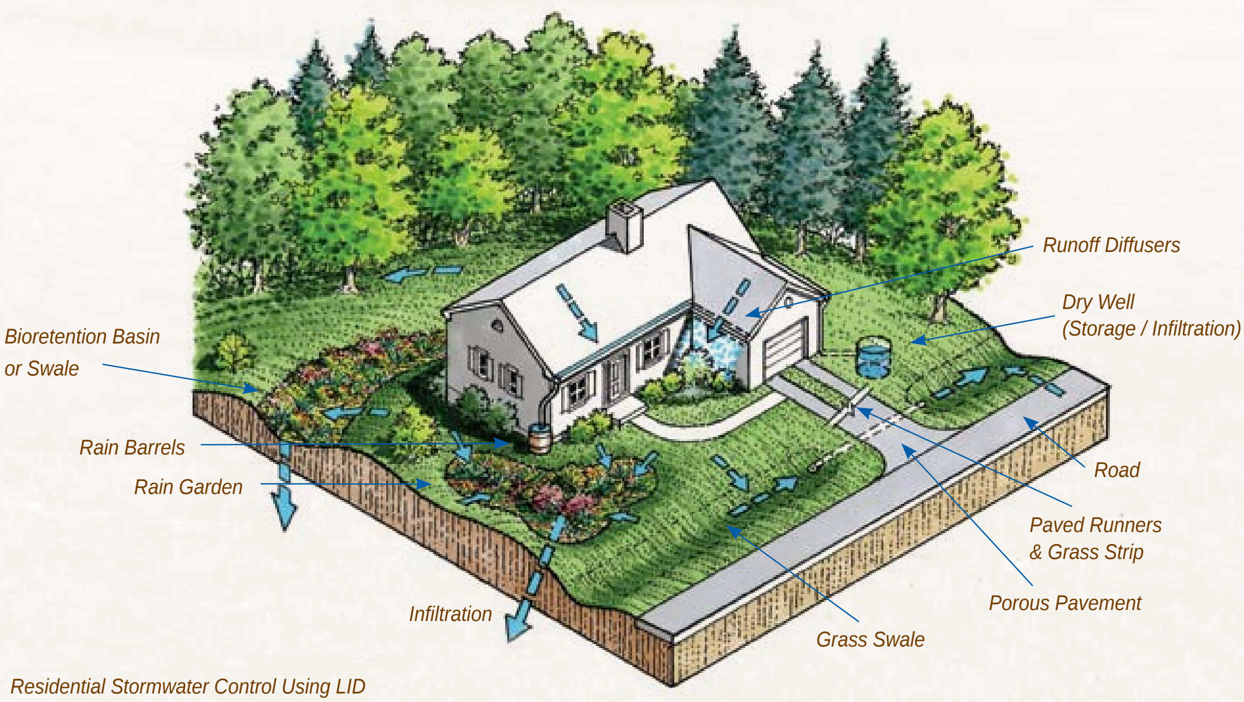
Conservation neighborhood

Developers, Architects and Engineers – Incorporate LID into your site plans for new developments or suggest it to the land owners. It will save them money, increase property values, protect water quality and improve the environment.



Residentail Code Measures

Local Governments – Adopt LID in stormwater management plans and ordinances.



Residential Stormwater Control Using LID

Homeowners and Citizens – Ask your local officials to adopt ordinances supporting LID practices. You can also find small-scale practices in this guidebook that you can implement on your property, which are inexpensive and easy to install. Examples include planting a rain garden or installing a rain barrel.

Studies

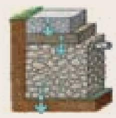
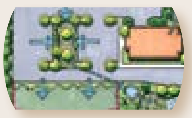
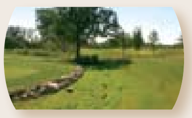
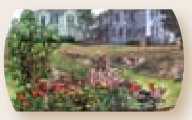
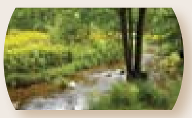
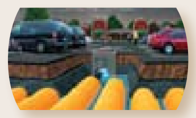
APPLICATION CASE STUDIES

Replanting may also be necessary in certain areas from year to year. It's also a good idea to incorporate barriers such as large stones to prevent foot and vehicle traffic from compacting the soil.

To illustrate how the LID techniques can be utilized in existing situations, three projects in the Grand Traverse region that were developed using traditional stormwater management practices are presented in an accompanying map as case studies. LID techniques described in this guidebook that the study team believes may have been appropriate to install have been placed on the various drawings, demonstrating how a LID approach could have resulted in a significantly different development. The three case studies are the Garfield Township offices, The Arbors residential complex and the Grand Traverse Mall.

Stickers have become a tool in recent years to facilitate exploring concepts in community planning workshops. Similarly, stickers illustrated with LID techniques are a useful tool in designing plans to manage stormwater on a development site. The illustrated LID techniques recommended for the Grand Traverse region are printed as a series of stickers for developers, planners and others to comment on proposed developments.

The Stickers *(Sheet included with this guidebook)*

Sticker	LID Technique	Sticker	LID Technique	Sticker	LID Technique
	Bioretention & Biodetention Basins		Bioretention Swales		Infiltration Trenches
	Conservation Site Plan		Infiltration Systems		Porous & Permeable Pavement
	Minimize Impervious Surfaces		Water Quality Swales		Structural Soils
	Source Control		Rain Gardens		Green Roofs
	Preserve Natural Vegetation		Flow-Through Planters		Water Harvesting & Reuse
	Preserve Existing Drainage Paths & Streams		Infiltration Basins		Underground Storage
					Utilize Low Impact Landscaping

** For more stickers, please contact The Watershed Center Grand Traverse Bay at 231-935-1514 or info@gtbay.org.*

Glossary

DESCRIPTIONS OF LID PRACTICES

Description of LID Practices

Conservation Site Plan: Concentrating development units to preserve open space and natural hydrological features. Often referred to as planned unit developments.

Minimize Impervious Surfaces: Narrowing roadway and sidewalk widths, and decreasing parking lot size.

Source Control: Minimizing nutrient and sediment runoff with street sweeping, only using slow-release fertilizers when necessary, and landscaping with native plants.

Preserve Natural Vegetation: Preserving as much natural vegetation as possible, which stores more water than over-manicured landscapes, reduces nutrient runoff and reduces the need to install stormwater controls.

Preserve Existing Drainage Paths and Streams: Preserving natural swales and small streams to trap nutrients and sediment during rain and snow.

Utilize Low Impact Landscaping: Properly preparing soils and planting native species to ensure long-term establishment of plants

Bioretention and Biodetention Basins: Shallow depressions containing soil and vegetation that retains and filters water.

Bioretention Swales: Shallow vegetated swales with a slope less than 0.5% to maximize water retention, filtration and percolation time.

Water Quality Swales: Flat, broad vegetated areas ideal for heavy sediment and nutrient loads where ground water recharge is not desired; usually lined to reduce ground water infiltration.

Rain Gardens: Bioretention basins on a residential scale planted with flowering perennials that tolerate wet soils.

Flow-Through Planters: Containers with impervious bottoms filled with gravel, soil and herbaceous plants to capture stormwater from roofs or sidewalks. Overflow valves are included.

Infiltration Systems: Trenches, drain fields, basins and dry wells that encourage runoff to flow downward into soil. Ideal for final stage after sediment has been removed. Differ from bioretention/detention in that primary use is for ground water recharge and reduction of surface runoff – nutrient removal is not a priority.

Infiltration Trenches: Excavated and filled with aggregate material to increase filtration – ideal for roof runoff or parking lots with low sediment load.

Infiltration Basins: Collect water in a basin prior to filtering it into the ground. Excellent for recharging ground water and cooling warm runoff. Tend to be smaller and designed for tight spaces/urban retrofits.

Porous and Permeable Pavement: Asphalt or concrete that absorbs runoff and recharges groundwater. Should not be used for contaminated runoff, impermeable soils or near drinking water supplies.

Structural Soils: A firm base for underneath paved areas that is permeable enough for tree roots to grow and to filter runoff. Also reduces urban heat island impacts.

Green Roofs: A roof wholly or partially covered by soil and vegetation placed on a waterproof membrane.

Water Harvesting and Reuse: Retention ponds, constructed wetlands or residential rain barrels that collect stormwater to use during dry periods for watering plants.

Underground Storage: Structures beneath parking lots, tennis courts and other structures that hold runoff for discharge to a storm sewer system at a controlled rate or for recharging ground water. Especially helpful when infiltration basins or biodetention basins are unsuitable.

Notes