LOW IMPACT DEVELOPMENT DESIGN GUIDELINES FOR THE NISQUALLY WATERSHED

Introduction

Western Washington communities are in the early stages of transitioning to a more natural approach to land development and stormwater management. The approach – Low Impact Development (LID) – is in response to the need to significantly reduce the harm caused to our environment by traditional development practices, while accommodating growth and the need for affordable housing. To date, most LID projects have occurred in more urbanized areas, however, the techniques are also applicable to rural environments, such as the Nisqually Watershed, which has more extensive stretches of undisturbed forest. Natural, pre-developed watersheds achieve a balance between overland stormwater flows, infiltration, storage, and evapotranspiration. LID strategies apply site and building development techniques designed to maintain this natural balance. Illustrations of the hydrologic cycle under natural and developed conditions are shown on the following pages.

Citizens of the Nisqually Watershed now have the opportunity to understand LID, why it is important, and how they can implement its techniques at their homesites and in their communities.

What is LID?

Conventional land development typically involves clearing and grading a site, which results in the removal of all vegetation, and compaction of soils. It involves paving areas for roads and parking, building structures, and landscaping areas with minimal amounts of topsoil. Engineers design stormwater facilities, such as curbs and gutters, underground conveyance systems and detention ponds to remove pollutants and to rapidly and efficiently drain the site.

Research shows that these conventional techniques have not proven entirely effective at managing stormwater to prevent damage to water quality. Pavement and other impervious surfaces prevent infiltration. High stormwater flows cause flooding, damage public and private property, and harm wildlife habitats for salmon and other fish and wildlife.

In contrast, LID design uses a site's natural features and specially designed best management practices to manage stormwater and to preserve the natural hydrologic functions of the site. These principles include the following design steps:

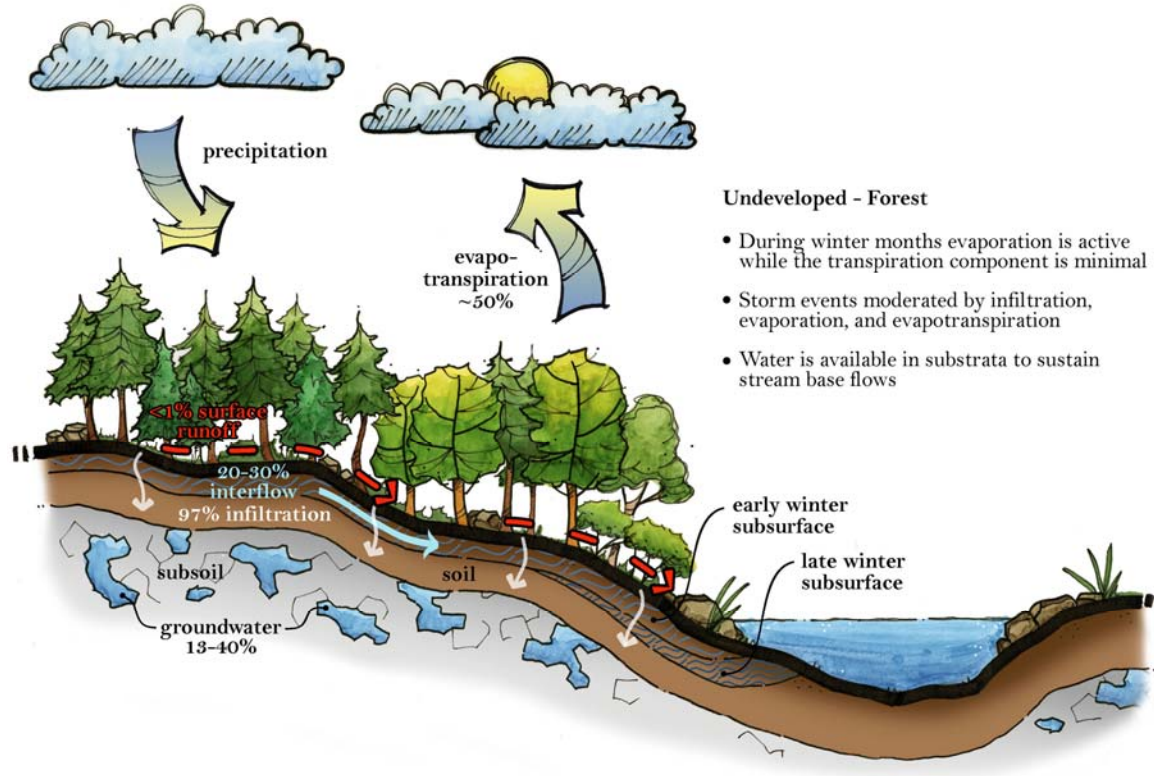
Assess and Understand the Site

Assess the site's topography, soils, vegetation and natural drainages, and divide the site into protected and developable areas. Protected areas include streams, wetlands, steep slopes and other critical areas. Apply adequate buffers to protect these areas.

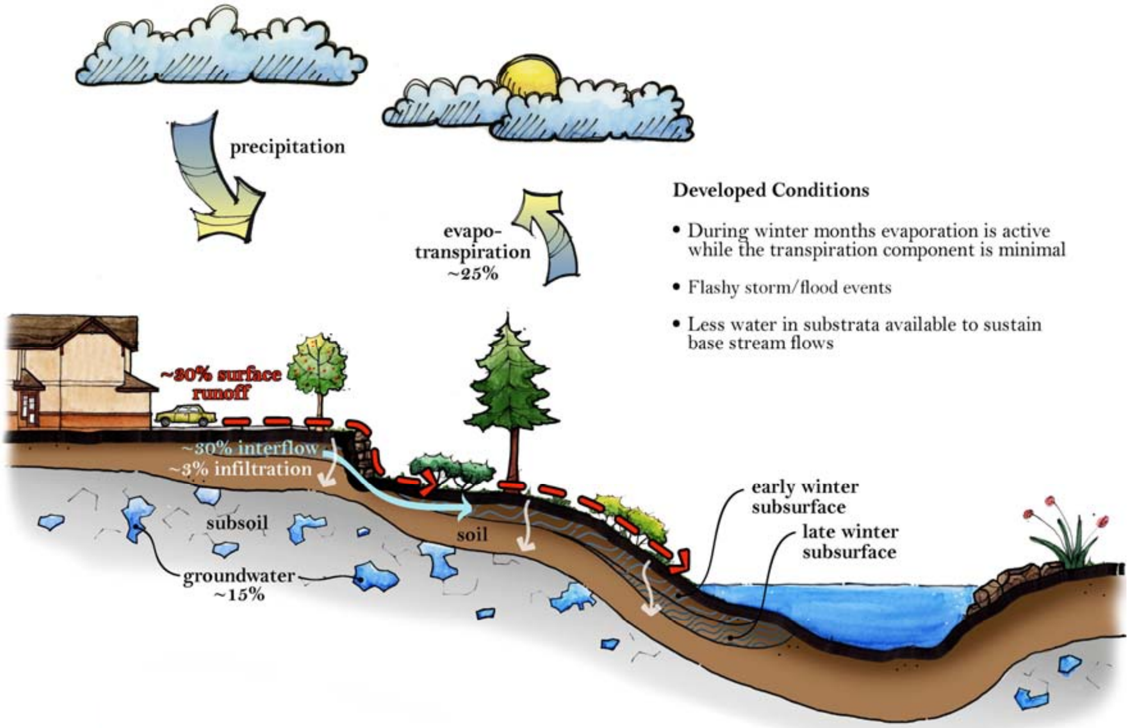
Protect Native Vegetation and Soils

Set aside a portion of the site's native vegetation and areas with soils that have a high infiltration capacity. These natural areas are nature's own excellent stormwater management systems, and if left undisturbed, will continue to manage runoff quite well. To protect native vegetation, clustered site planning is used.

Estimated Annual Water Balance for Native Puget Sound Lowland Forest

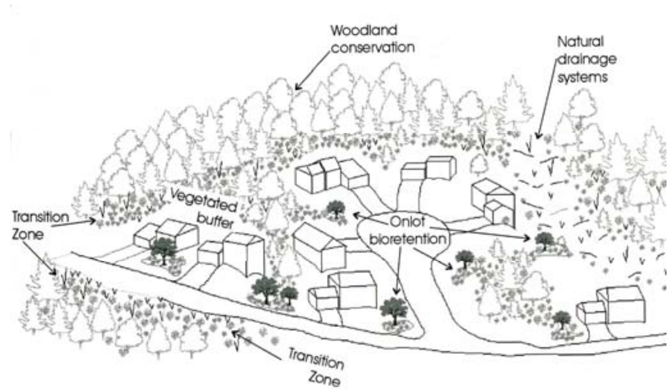


Estimated Annual Water Balance for Suburban Residential Development



Minimize and Manage Stormwater at the Source

Minimize areas of impervious surfaces such as roads, rooftops and parking areas by designing shorter, narrower roads, using various permeable pavements, and installing green roofs or rainwater catchment systems. Manage remaining runoff by disconnecting the impervious surfaces from one another, and directing runoff to bioretention areas (such as rain gardens), amended soils, native vegetation or other types of infiltration areas. This can greatly reduce the need for piped conveyance, as well as reduce or eliminate the need for large storm detention facilities.



LID Design Techniques

The home, business or development that includes LID design practices causes less harm to area streams, wetlands and wildlife habitat. Rainwater can better infiltrate into the ground to recharge drinking water supplies, streams and wetlands. The site is greener and more attractive, with open spaces that appeal to potential buyers.

Depending on the type of development and site constraints, LID techniques can reduce stormwater and site development costs by 10 to 25 percent compared to conventional approaches. LID designs reduce development costs by:

- Reducing impervious surfaces such as roadways, curbs and gutters.
- Decreasing the use of storm drain piping and inlet structures.
- Eliminating or decreasing the size of large stormwater ponds.
- Reducing the amount of clearing and grading.
- Enabling more efficient use of water for irrigation.

LID applications provide an avenue for communities to maintain Growth Management Act (GMA) mandated densities and many of the characteristics of truly livable neighborhoods. The concepts of clustering development were originally promoted for efficient provision of roads and utilities. Clustering also allows for retention of larger open space areas that can be left in their natural state, and reduced impervious areas. Since stormwater management is controlled on each lot using small dispersed and nonstructural systems, the portion of the buildable area that would have been used for stormwater ponds can now be recovered and used for buildings, parking lots, open spaces or habitat enhancements.

The most significant benefits of LID applications will be positive environmental effects on the Nisqually Watershed. Encouraging a site planning and design ethic that works toward maintaining the water balance achieved in nature will be the most significant contribution of LID projects.

Low Impact Development Tools for the Nisqually Watershed

Site Planning

LID site planning strategies and techniques facilitate the development of site plans that are adapted to natural topographic constraints; maintain lot yield; maintain pre-developed hydrologic functions; and provide for aesthetically pleasing, and often less expensive, stormwater management controls.

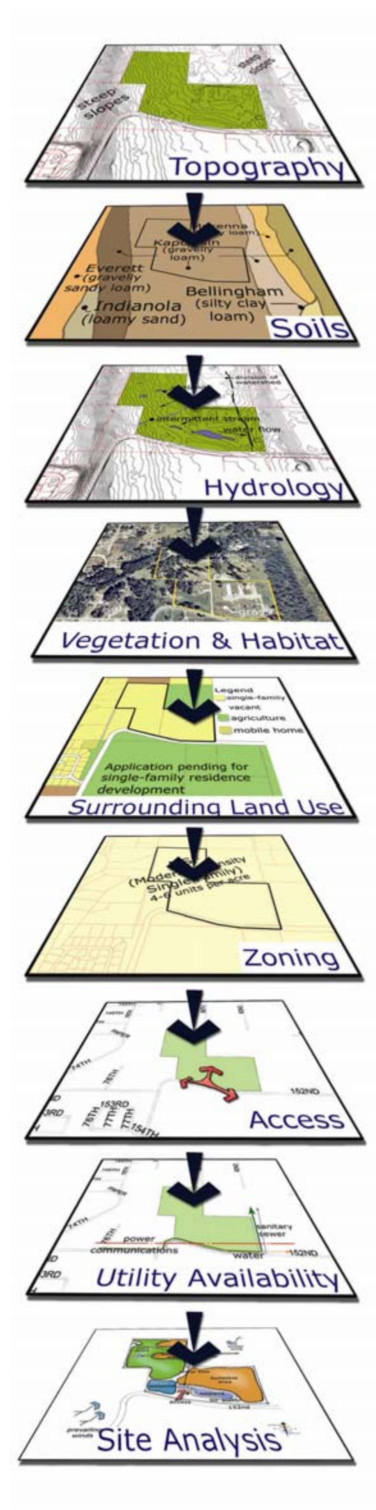
The LID design process assesses existing site soils, native vegetative cover, sensitive areas and drainage characteristics of both the site and surrounding watershed. Consistent with the overreaching goal of LID, the design process focuses on protecting, maintaining and/or restoring natural site features.

Site Analysis

The first step in LID site planning is to determine the attributes of a particular site. What are the primary site characteristics that must be identified to design the site for optimal functioning as a surface water system, as well as for habitat value and other public benefit? Areas of analysis include:

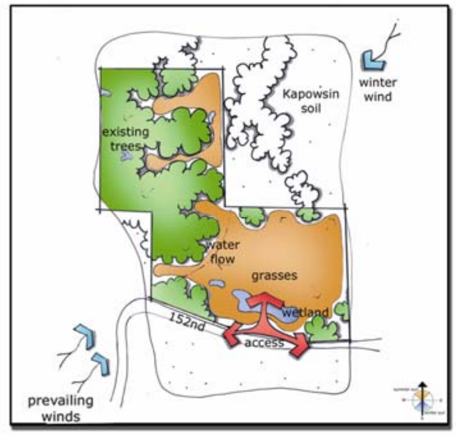
- Topographic analysis to identify areas most appropriate for circulation, buildings, natural cover and surface water flows.
- Geotechnical analysis, to highlight the most effective soils for stormwater storage, conveyance and infiltration; soils most structurally suitable for pavement and buildings; and the suitability of soils as a growing medium.
- Assessment of existing drainage patterns, including water bodies, streams, rivers, natural drainage swales, groundwater flows and any buffers that may be required under critical areas regulations.
- Delineation and classification of existing streams and wetlands and required buffers.
- Identification and inventory of existing vegetation and habitat areas, particularly those for critical wildlife species.
- Identification of other site features, such as aquifer recharge areas and areas of scientific or cultural importance.

The Site Analysis Process



- Analysis of the built environment, including land uses within and surrounding the site and available street and utility infrastructure.

- Analysis of the regulatory environment, including allowed uses, density ranges, development standards and critical areas requirements.



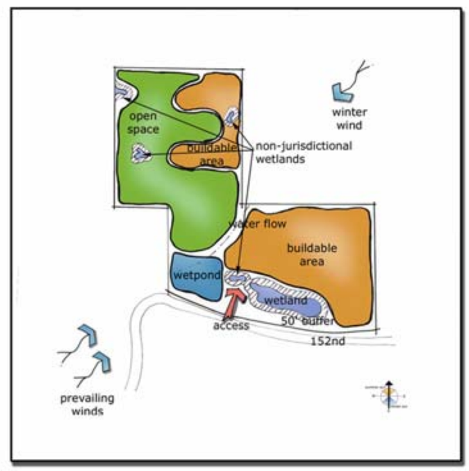
Composite Inventory

Site Design

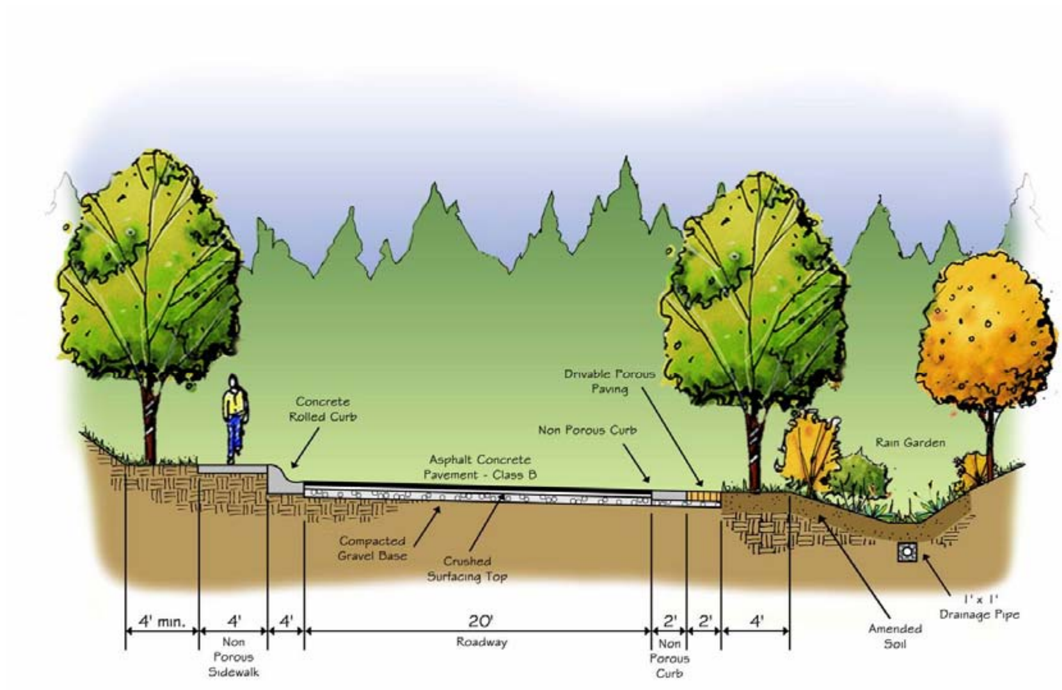
LID site design uses information provided by the site analysis to determine the developable area and areas to be protected. After determining the area of the site to be developed, a conceptual site design can be prepared to define the location of drainage features including bioretention areas, access and circulation facilities and building placement.

<u>Circulation</u>

Among the primary concepts of low impact development are minimizing impervious areas and eliminating effective impervious surfaces by providing alternatives to piped conveyance and traditional curb and gutter design. Among the design considerations are reduced roadway widths; use of pervious paving materials; and long, open paths for storm conveyance.



Composite Analysis



LID Roadway Cross Section

Site Clearing and Grading

Site preparation is an important element of LID to protect and maintain attributes that contribute to the natural surface water flows and infiltration functions. Areas for consideration include:

- Identification of site areas most conducive to infiltration via geotechnical survey.
- Strategies to limit topsoil removal and soil compaction.
- Strategies for preserving natural depression areas to maintain natural stormwater retention and infiltration areas.
- Strategies for erosion control during construction activities.
- Strategies to protect natural area vegetation during the development process.
- Strategies to rehabilitate soils in disturbed areas.

Each site has unique characteristics and opportunities for control. The LID concept encourages innovation and creativity in the management of site planning impacts.

Landscape Elements

Landscape elements are critical to the successful functioning of LID. Areas for consideration include:

- Soil amendment to increase its ability to hold water and reduce the need for fertilizers and pesticides.
- Reforestation of previously cleared areas to recreate forest cover conditions on portions of the site intended for natural open space.
- Biofiltration areas to remove pollutants and suspended solids in the surface water stream.
- Selection of native or ornamental plants to limit the need for supplemental watering, fertilizers and pesticides. Lists of recommended plants may be included as a reference.
- Irrigation strategies to make the most efficient use of potable water used as supplemental irrigation, as well as water collected from downspouts and used on-site.

Building Design

Building design may include standards and recommendations for employing LID technologies, including:

- Low Impact Foundation Technology (LIFT).
- Pervious pavement.
- Decks versus patios.
- Vegetated roofs and cisterns as strategies for minimizing or retaining roof runoff.
- A variety of green building technologies including more efficient building framing systems, recycled building materials, use of sustainable building products, and use of low-flow water fixtures

Soil Management/Conservation

Soils are unique ecosystems in their own right and provide important hydrologic and ecologic functions. Under conventional site development practices, topsoil is typically stripped from a site and disposed of or stockpiled. Often, very thin layers of topsoil are placed over hard-pan or compacted soils, then hydroseeded for lawn and yard areas. The result is removal of a functioning water quality and infiltration system and replacement with a lawn area that poorly infiltrates or tolerates drought and contributes to excessive storm runoff and poor water quality.

In LID practices, soils are preserved and rehabilitated to maintain their natural filtering capabilities for improving water quality, and regeneration of groundwater resources. Soils that are most conducive to infiltration are identified through geotechnical survey. Stripping of topsoil for the purpose of infiltration should be limited to areas identified as conducive to infiltration. Strategies are developed for preserving natural depression areas to maintain natural stormwater retention and infiltration areas; and to limit topsoil removal and soil compaction. During construction activities, erosion control strategies are adhered to and natural vegetation areas are protected.

Where soils are disturbed, they are later rehabilitated and/or enhanced through soil amendments. Amended soils have compost tilled in to restore natural capacities to treat, store and infiltrate water. The Stormwater Management Manual for Western Washington (Best Management Practice T5.13) recommends breaking up at least four inches of subsoil and tilling ten percent dry weight of compost into the top eight inches of topsoil.

Vegetation Retention

Vegetation plays an important role in controlling site hydrology. In addition to protecting sensitive areas, vegetation help to reduce stormwater runoff impacts by trapping sediment and sediment-bound pollutants, providing some infiltration, and slowing and dispersing stormwater flows over a wide area.

On the LID site, large, contiguous open space areas are preserved in their natural condition. Large vegetated buffers of sensitive areas are protected and enhanced; individual open infiltration systems are landscaped with native plants (rain gardens); and curbs and gutters are replaced with green roadway bioswales.

Vegetation plays an important role in controlling site hydrology

Minimizing Impervious Areas

Impervious areas in a conventional development typically cover more than 60 percent of a site and include roadways, driveways, sidewalks, rooftops and compacted soils. Minimizing impervious areas reduces the volume of drainage and required conveyance and infiltration systems.

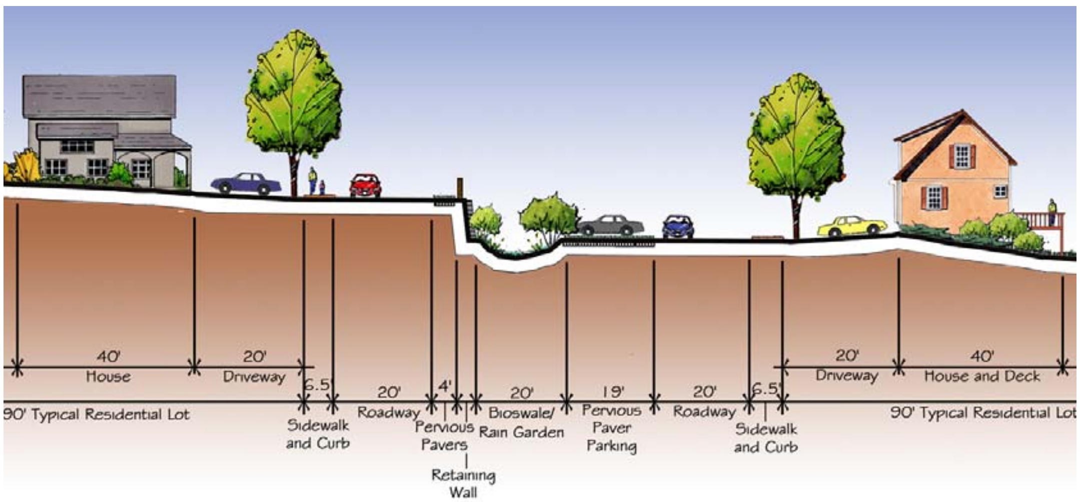
Development impacts can be reduced through minimal disturbance techniques that include the following:

- Reduce paving and compaction of soils.
- Minimize the size of construction easements, material storage areas, and site stockpiles within the developable area during the construction phase of a project.
- Site buildings, and clear and grade to avoid removal of existing trees, where possible.
- Minimize imperviousness by reducing the total area of paved surfaces.
- Delineate and flag the smallest site disturbance area possible to minimize soil compaction on the site, and restrict temporary storage of construction equipment in these areas.
- Disconnect as much impervious area as possible to increase opportunities for infiltration and reduce water runoff flow.
- Maintain existing topography and natural drainage courses to encourage dispersed flow.
- Dispersion from driveways and/or rooftops into native vegetation areas that are protected from future development by some type of legal mechanism, such as a covenant.

Narrower streets and pervious pavement reduce impervious areas.

Alternative Roadway Layout

Roadway layout can have a significant influence on the total imperviousness and hydrology of a site. Traditional rural roadways feature narrow streets and infiltration ditches or bioswales for runoff. This is a good low impact practice that has been replaced in urban areas with large, paved cross sections. A typical suburban residential roadway cross section is 60 feet, including 36 feet of roadway with curb and gutter, sidewalks on both sides of the road, side street parking and landscape strips. LID alternatives include reducing pavement widths to 20 feet, more or less; eliminating concrete curb and gutter; limiting sidewalks to one side; and reducing on-street parking by providing adequate off-site parking or limiting parking to one side of the street.



LID Roadway Cross Section

Driveways

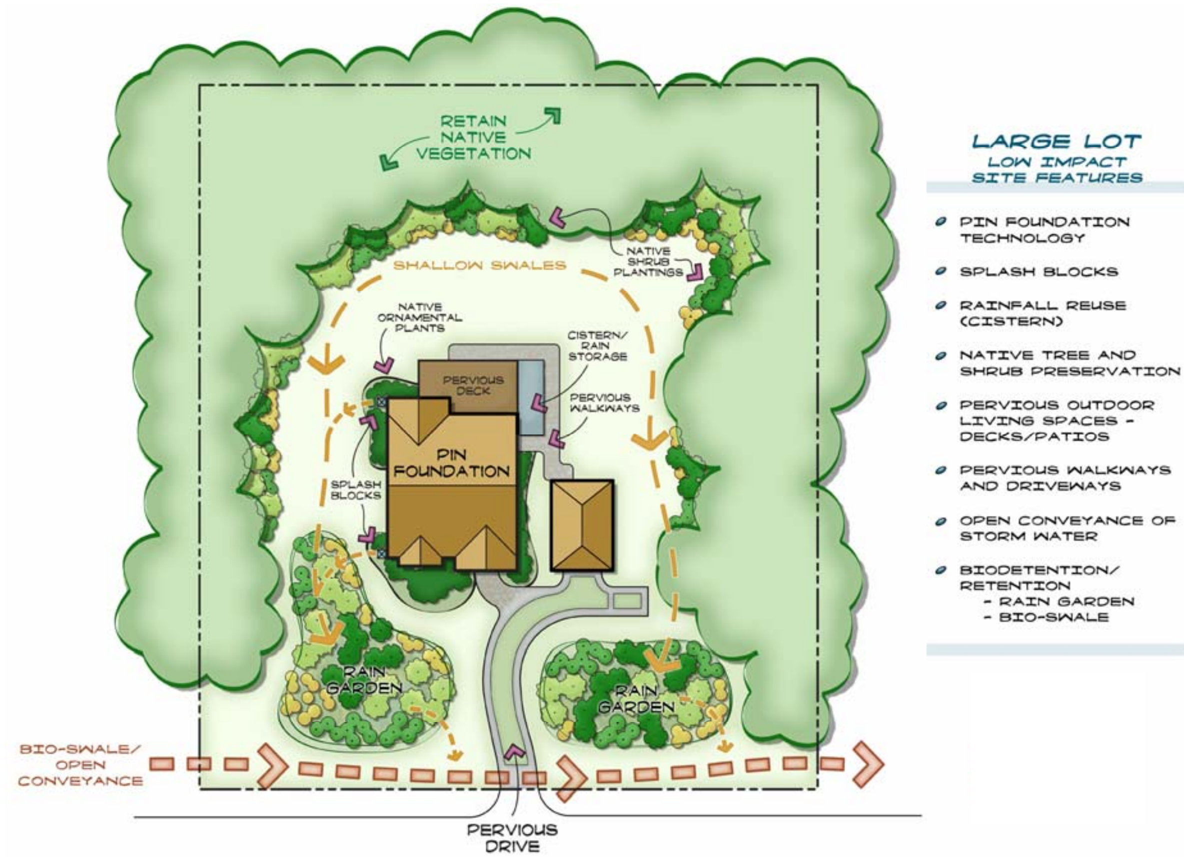
Driveways can also be designed to reduce imperviousness. Options include the use of shared driveways, limiting widths, minimizing building setbacks to reduce driveway lengths, and using pervious materials.

Pervious Pavement Technologies

Many products can replace conventional pavement surfaces to reduce impervious areas. The most common material is gravel, often used for private roads and driveways. Different pavement systems have different properties and ranges of suitable applications. Pervious concrete, for example, is a porous concrete paving material that permits rain and stormwater runoff to percolate through it, rather than running off into storm drains. It has a higher aggregate dimension and contains voids that add strength and allow water to permeate to the subgrade. It can handle from 2 to 10 gallons of water per minute, enough to manage almost any conceivable rainfall event. Its natural insulation factor reduces the temperature of paved areas, mitigating the heat of runoff to nearby water bodies. Benefits sited by the EPA include better infiltration, groundwater recharge, reduction in runoff volume, and treatment of stormwater for pollutants. Pervious concrete is best suited to low traffic areas such as driveways, sidewalks and parking lots. Other products that reduce imperviousness include brick pavers, plastic grid pavers with a grass surface layer, cement grid pavers, and cast-in-place concrete grid pavement. In all applications, proper preparation of the subgrade is imperative to performance.

Site Footprints

Development impacts can be reduced by minimizing a site's footprint. For example, homes that are built tall, rather than wide, have reduced rooftop surface areas and reduced impervious areas. Vegetating the rooftops also serves to reduce impervious areas (see Vegetated Roofs, below).



Managing Storm Drainage

The key to stormwater management on an LID project is to manage it where it falls, where the impact or disturbance is generated. LID focuses on the evaporation, transpiration and infiltration of stormwater on-site through small, disconnected and evenly distributed systems. This approach is one of the building blocks of low impact development.

The cost benefit of this approach can be substantial. Traditional stormwater management focuses on large, end-of-pipe systems and there is a tendency to overlook the consideration of small, simple solutions. These simple solutions and systems have the potential to be more effective in preserving the hydrologic landscape, and they can offer significant advantages over conventional engineered facilities such as ponds or concrete conveyances. By using materials such as native plants, soil and gravel, these systems can be more easily integrated into the landscape and have a more natural appearance than engineered systems.
Smaller facilities tend to feature shallow basin depths and gentle side slopes, which also reduce safety concerns. The integration of these facilities into the landscape throughout the site offers more opportunities to mimic natural hydrologic functions and add aesthetic value. The use of these landscape

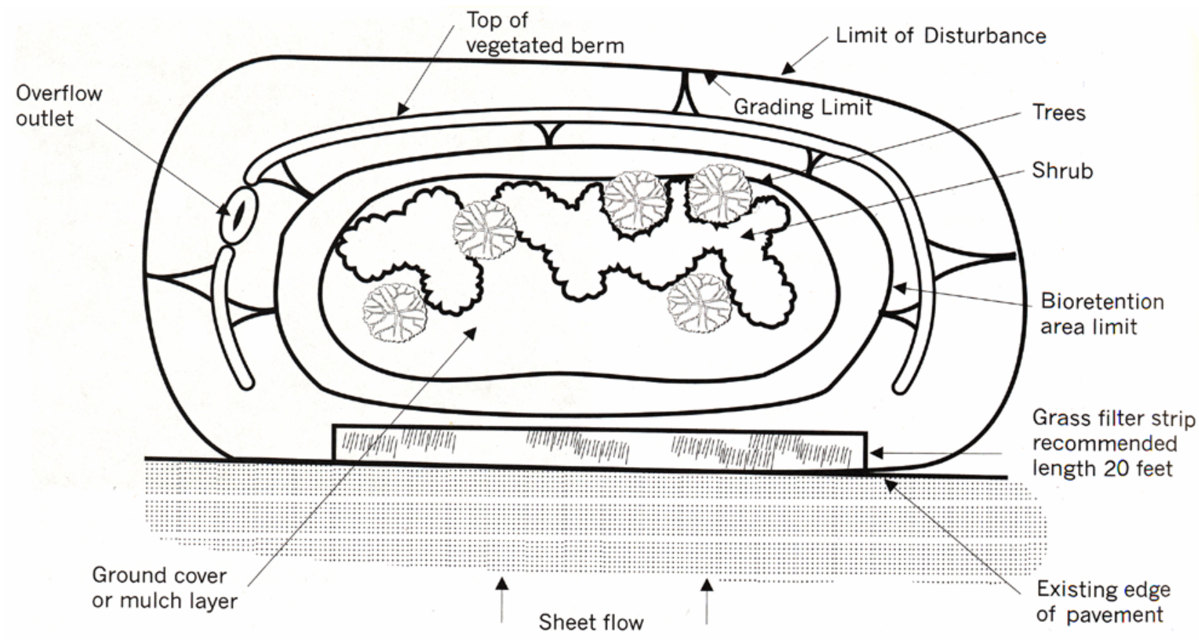
features can result in significant maintenance and upkeep savings to a homeowners association, municipality or landowner.

There are several techniques that can be adapted to a site, including:

- Open drainage systems such as roadway bioswales.
- Bioretention areas and rain gardens.
- Dry wells and splash blocks.
- Capture and reuse of roof drainage.
- Low Impact Foundation Technology.
- Vegetated Roofs.

Bioretention and Rain Gardens

Bioretention areas are shallow depressions with a conditioned soil bed and plantings that manage and treat stormwater runoff. This technique combines physical filtering properties of soil and vegetation, as well as adsorption with biological processes. The system can include components such as a pretreatment filter strip of grass channel inlet area, a shallow surface water ponding area, a bioretention planting area, a soil zone, an underdrain system, and an overflow outlet structure.



Bioretention Cell Design

The bioretention cell shown above is perhaps the best example of a multifunctional practice and illustrates a number of functions and benefits. First, the tree canopy provides interception and ecological, hydrologic and habitat functions. The 6-inch storage area provides detention runoff. The organic litter/mulch provides infiltration of runoff, removal of pollutants through numerous processes, groundwater recharge, and evapotranspiration through the plant material. Rain Gardens are bioretention areas that are designed to complement the landscape, such as yard areas or common open space areas.

Rain Garden on a Residential Lot

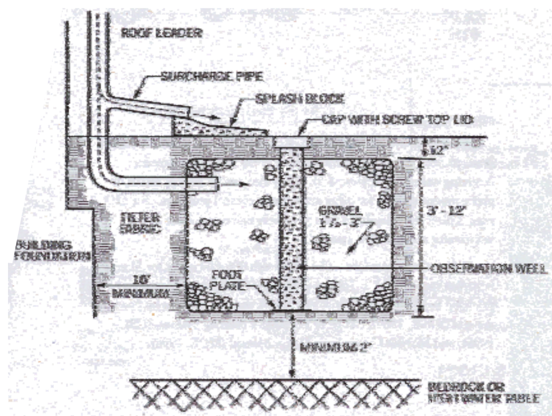
Many roadways in the Nisqually Watershed direct runoff to ditches lined with a combination of grass and gravel. This open drainage system provides some infiltration capacity, but is largely designed to convey runoff to a downstream source. Roadside bioswales that feature the use of soil amendments and native plantings are more effective infiltration systems.

Example of a roadway bioswale in urban area

Dry Wells and Splash Blocks

Conventional rooftops are constructed with gutter systems that are tight-lined to a stormwater drain for conveyance off-site. The LID option channels rooftop rainwater to a splash block that serves to disperse the runoff over a larger area for infiltration; typically, the area includes a dry well or rain garden.

A dry well consists of a small excavated pit backfilled with aggregate, usually pea gravel or stone. Dry wells function as infiltration systems used to control runoff from building rooftops. Dry wells also provide water quality treatment by processes related to soil infiltration, including adsorption, trapping, filtering, and bacterial degradation.



Dry Well Design

Splash Block

Roof Drainage Capture, Reuse

Rain barrels are low-cost, effective, easily maintainable retention devices applicable to both residential and commercial/industrial LID sites. Rain barrels provide storage of runoff for later reuse in lawn and garden watering.

Stormwater runoff cisterns are roofwater management devices that provide retention storage volume in underground storage tanks. On-lot storage with later reuse of stormwater also provides an opportunity for water conservation and the possibility of reducing water utility costs.

Rain Barrel

Low Impact Foundation Technology

Conventional foundations are constructed through a process that begins with clearing all topsoil and vegetation, wholesale grading, and soil compaction of the building site. These activities and conventional concrete slab-on-grade foundations decrease the soil's ability to naturally store and filter rainfall and disrupts or diverts natural drainage flow.

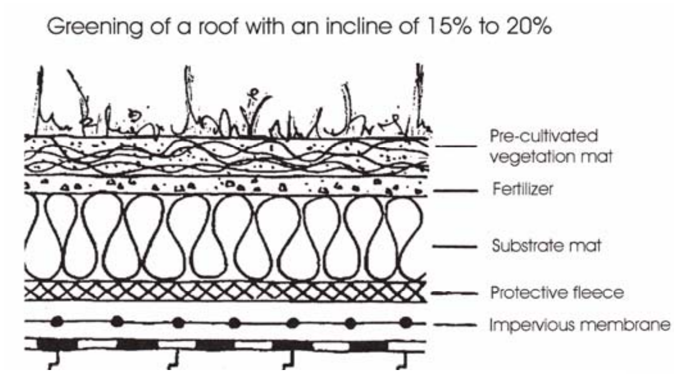
Using a "pin" foundation, existing soils remain in place, while small diameter steel piles reach to the deeper bearing material below - without ever digging down. The technology makes minimal impact and leaves the existing patterns of surface and ground-water flow undisturbed, allowing the soils to continue to absorb and process rainwater. Grading is left to smaller equipment, that "feathers" the existing surface soils without stripping them away. Lot by lot compaction requirements are reduced. Excavation is not necessary, and generating less dirt (and mud) means reduced erosion control. Homes built with a pin foundation are completely conventional.

The system uses 20 percent to 30 percent less concrete; reduces site materials such as drain pipe and imported gravels; and cuts trucking, excavator and dozer times.

Low Impact Foundations Reduce Site Disturbance

Vegetated Roofs

"Green" or vegetated roofs establish a foundation for native vegetation and ground-level life on the roof of a building. They increase the insulation value of the roof, thus reducing mechanical equipment size and operating costs. They also slow stormwater runoff from the roof of the building, decreasing the impacts of runoff.



Rooftop Vegetation Cross Section

Vegetated roofs consist of pre-cultivated vegetation mats which provide the following benefits:

- Air quality improvement - up to 85 percent of dust particles can be filtered out of the air.
- Cooler air temperatures and higher humidity can be achieved through natural evaporation.
- 30 to 100 percent of annual rainfall can be stored, relieving storm drains and feeder systems.

Vegetated roofs have structural requirements for roof design, including pitch and structural enhancements.

Vegetated Roof in Practice

Implementation

Despite the promise of LID, the vast majority of new development projects each year still rely on traditional stormwater management facilities without considering LID techniques. One reason is that most local government development regulations do not allow for certain LID practices, such as narrower roads or open road sections without curbs and gutters. In addition, many engineers and developers are not familiar with LID techniques and continue to rely on better-known conventional practices.

Some of the major components of implementing the LID approach include:

- Develop a hydrologic analytical methodology to demonstrate the equivalence of LID with conventional approaches.
- Develop new road standards which allow for narrow roads, open drainage and cluster techniques.
- Streamline the review process for innovative LID designs to allow easy modification of site, subdivision, road, and stormwater requirements.
- Facilitate public meetings and workshops with citizens and non-governmental organizations to determine the unique wishes and vision of the community.
- Develop a public education process to inform property owners about how to prevent pollution and maintain on-lot BMPs.
- Develop legal and educational mechanisms to ensure that BMPs are maintained.
- Demonstrate the marketability of green development.
- Demonstrate the cost benefits of the LID approach.
- Provide training for regulators, consultants, public and political leaders.
- Conduct research and monitoring to demonstrate the effectiveness of bioretention BMP's.

Training opportunities are available from sources such as the Puget Sound Action Team, Washington State University, and private consultants. In Western Washington, several local agencies are working to implement LID and have accomplished many of the above tasks. These jurisdictions include:

- Pierce County
- King County
- Island County
- Snohomish County
- City of Olympia
- City of Lacey
- City of Tumwater
- City of Issaquah

Adopt LID Zoning, Land Use, Subdivision, and Other Local Regulations

Zoning requirements are intended to regulate the density and geometry of development, specifying roadway widths, parking and drainage requirements; and defining natural resource protection areas.

The LID site planning process recognizes that in most instances, LID approaches need to meet local zoning requirements. However, typical conventional zoning regulations are often inflexible and restrict development options regarding certain site planning parameters. Consequently, local planning agencies that wish to optimize the environmental and economic benefits provided by the LID approach will want to consider adopting environmentally sensitive and flexible zoning options that facilitate the use of LID technology.

The LID approach employs a number of flexible zoning options to meet the environmental and financial objectives of development without impeding growth. The use of these options provides added environmental sensitivity to the zoning and subdivision process over and above what conventional zoning can achieve. Alternative zoning options, such as those summarized in the table below, include overlay districts, performance zoning, impervious overlay zoning, and watershed-based zoning to allow for the introduction of innovative development, site layout, and design techniques.

Alternative Zoning Options

Zoning Option	**Functions Provided**
Overlay District	Uses existing zoning and provides additional regulatory standards.
Performance Zoning	Flexible zoning based on general goals of the site based on preservation of site functions.
Incentive Zoning	Provides for give and take compromise on zoning restrictions to allow for more flexibility to provide environmental protection.
Impervious Overlay Zoning	Subdivision layout options are based on total site imperviousness limits.
Watershed-Based Zoning	Uses a combination of the above principles to meet a predetermined watershed capacity or goal.

The City of Tumwater has enacted a “”Zero Effect Drainage Discharge” design standard. The standards encourage developers to achieve “zero effective impervious surface”[1]. The ordinance provides provisions for deviations from standard development regulations that include the following criteria:

- The standards recommend that at least 65% of the native forested conditions be retained over the site; that the forest is used to buffer impervious surfaces and is not clustered on the site or segregated from impervious surfaces.
- Underlying zoning density be maintained.
- Local access streets (ADT less than 200) are allowed to be constructed as one lane, 13-foot roadways for looped road sections with additional 3-foot shoulders on each side; or two lane, two-way, 20-foot wide for dead end and cul-de-sac road sections.
- Curbs may be omitted.
- Road rights-of-way include forested buffer of 50 feet minimum. All roads, turnouts for emergency vehicles, on-street parking stalls and driveways shall be constructed with impervious surfaces.

[1] Zero Effective Impervious Surface is defined as impervious surface reduction to a small fraction of that resulting from traditional site development techniques such that traditional drainage collection systems are not necessary.

In the City of Olympia, the Council adopted mandatory low impact development regulations to prevent further damage to aquatic habitat from urban development in the Green Cove Basin. The comprehensive policy revision covers development density, impervious surface coverage, lot size, open space/tree retention, street design, street width, block sizes, parking, sidewalks, and stormwater management requirements.

Pierce County has developed an LID chapter for their Stormwater Management and Site Development Regulations, which is currently under environmental review. The chapter establishes a performance goal, objectives and prescriptive standards for LID. The chapter discusses how LID can be considered at each phase of development including site planning; vegetation retention and reforestation; site clearing and grading; roads, parking and sidewalks; and building design. It also provides best management practices and monitoring requirements. In addition, the chapter addresses ongoing management and maintenance needs, and education of homeowners.

Stormwater Management Policies

Stormwater regulations and design manuals govern the design of stormwater facilities calculated using mathematical models to forecast runoff volumes, peak runoff rates, flow frequency duration and water quality impacts. Conventional facilities are sized and designed based on this information.

LID techniques significantly reduce runoff rates and produce different results. LID stormwater policies and regulations can allow for modifications or deviations from standard design practices, and credits or incentives for their use. In Washington State, a new Stormwater Management Manual was completed in 2005 by Department of Ecology (Ecology). Ecology is in the process of evaluating LID and offering credits when the technologies are used, however, to date an LID hydrologic model has not been tested or adopted. Local governments can offer incentives for projects that propose LID stormwater practices, such as:

- Reducing stormwater utility fees.
- Establishing permit conditions that fulfill the best management practices for LID surface water rate control in lieu of submitting a drainage narrative.
- Allowing for submittal of a drainage narrative rather than a preliminary drainage plan.
- Eliminating the need for downstream analysis.