# Chapter 10. DESIGNING FOR WATER QUALITY

This chapter is provided to bring together many elements of effective site design for water quality that until recently have often been viewed as separate subjects. To meet the water quality requirements stipulated in Chapter 9 of this Design Manual, the site designer will be prudent to approach water quality as an integral part of the design process from the initiation of the project. In the previous version of this Design Manual (effective January 2013), this chapter was devoted to explaining new concepts in the field of low impact development (LID). Today, those developments are now far more common and are understood to fit more naturally into the overall site design process. This chapter assumes that LID concepts will be a necessary part of meeting the County's post-construction water quality requirements. While many of the concepts discussed in this chapter are also applicable to the construction phase, the focus of this section is on post-construction.

LID, most commonly associated with the use of Green Infrastructure (GI), and also known as Environmental Site Design (ESD) or simply Better Site Design, is a concept that was developed to mitigate the effects of urban development on the health of the environment. Green initiatives use holistic planning to reduce the "footprint" of a site's impervious areas (buildings, parking lots, etc.), pollutant load, energy consumption, and overall environmental impact.

There are many names, organizations, and regulations promoting environmental sustainability and conservation, whether through initiatives like the Smart Growth initiative, which encourages mixed land use to promote urban renewal and conservation, ratings systems like Leadership in Energy and Environmental Design (LEED) promoting energy efficiency and sustainability, or concepts like Low-Impact Development, which uses better site design techniques to maintain the natural hydrology of a site from its pre- to post-developed state. These initiatives create healthier work and living environments, increase the health of our rivers, lakes, and streams, conserve natural resources, help reduce $CO_2$ emissions, and make our community more sustainable.

## 10.1 Incorporating LID throughout the Design Process

Because Low Impact Development techniques are most effective when incorporated as a part of the overall site design, they must be considered at every stage of design. The design process differs from project to project, but the vast majority of projects include several common stages. At each milestone, beginning with project initiation, LID design concepts should be implemented. The following three major project phases will be used to describe how LID concepts should be used throughout the design process.

1. Preliminary engineering: LID processes should be in mind from the project's conception. A commitment to water quality design is best made at the beginning when incorporating GI features will be least constrained by other design decisions.
2. Site layout and stormwater quantity design: the greatest opportunities to incorporate LID measures come when deciding the site layout. Codes, design guides, and site requirements dictate much of the site's layout, so making room for smaller, distributed water quality controls at this point is critical. One of the major benefits of GI is that it can reduce the necessary size of the traditional piping and detention structures required for water quantity control, so the quantity calculations should be done concurrently with the quality calculations in an iterative process continuing through the final design.
3. Final design: details should be tailored to the specific applications, including instructions to contractors and owners to ensure that the facilities will function as intended after construction.

## 10.2 Preliminary Engineering

A site incorporating LID principles generally produces a much smaller peak discharge rate and a lower volume of runoff than a site using traditional stormwater management methods. In a traditional design, the increased rate and volume of runoff is concentrated by pipes and detained in a single large structure at the outfall of the project. In an LID approach, stormwater runoff is managed near the source ("source-controlled") in a number of small, landscape-like features. These features encourage infiltration, lengthen the time of concentration, and retain flow to create a hydrologic landscape that approximates the pre-development conditions as nearly as possible. These source treatment structures should ideally connect to natural drainage ways or drainage structures that mimic natural drainage ways.

Now is the time to thoroughly review all water quantity and quality requirements of the project. Table 9-1 should be consulted before beginning any of the design, as it will dictate the baseline level of water quality treatment required. Downstream water quality monitoring stations should be checked and any impairments, TMDLs, or other special water quality considerations should be identified from the beginning to ensure that the correct water quality requirements will be met. Waiting until the end of the design process to establish water quality criteria could result in a significant amount of re-work or more costly solutions.

This is also the best time to decide with the site owner on the level of sustainability that should be incorporated into the overall design. Assuming the County's requirements are the minimum level of water quality treatment, it is good practice to decide on other environmental and sustainability goals for the project. In order to achieve compliance with County requirements and to meet other goals, the following examples of LID site planning considerations should be incorporated at this stage in the process:

1. Map existing site with drainage areas, soils, and land covers.
2. Identify off-site drainage and potential methods of diverting it around the site. Alternatively, if the off-site drainage area is developed, it may be possible that treating this runoff will meet water quality requirements more efficiently than a more traditional approach, based on possible BMP locations to treat this runoff and the pollutant loading of the off-site area versus the proposed site area.
3. Identify areas of the site that could be left undisturbed. These areas do not have to be considered in water quality calculations if they are not disturbed, reducing the level of treatment required.
4. Identify areas of the site most suitable for BMPs (more permeable soils and locations along pre-existing, natural drainage ways.)
5. As site layout options are considered (more detail in the next section), identify opportunities to reduce the overall impervious area, reduce the amount of impervious area directly connected to the stormwater system, place impervious areas on less permeable soils, and seek other ways to reduce the volume, peak flow, and pollutant concentrations in the stormwater runoff.

During the analysis described above and transitioning into the next phase of the design process, the following techniques should be utilized:

- Maintain natural drainage patterns
- Direct runoff to depressed areas for infiltration
- Preserve existing trees
- Reduce impervious areas
- Locate BMPs in soils with the highest permeability
- Disconnect impervious areas from one another
- Limit clearing and grading as much as possible
- Locate impervious areas on less permeable soils
- Maintain the existing natural terrain and avoid construction of or in steep slope areas (>15%)
- Use "site fingerprinting" techniques to preserve tree canopy and natural vegetative buffers (see Section 10.3.2 below)
- Re-vegetate cleared and graded areas
- Avoid concentrating flow into pipes or channels

## 10.3 Site Layout and Stormwater Quantity Design

Utilizing LID techniques can greatly reduce the size of detention practices necessary for flood control. Any GI practices planned during the site layout and grading phase should be incorporated into hydrology and hydraulics (H&H) modeling. This is also the stage for building and running a water quality model to ensure all water quality requirements are met. The following practices are options that are helpful for both water quality and flood control:

- Swales, check dams, and diversion structures
- Cisterns
- Rooftop and parking lot storage
- Terraces designed for and used as detention
- Infiltration trenches

While LID concepts are simple, they are also “open-ended;” there are no specific methodologies, sizing methods, or specifications that a designer can follow to arrive at a final design that is considered LID. However, an understanding of some tools to help achieve the underlying concepts can be invaluable. Several of these tools, concepts, and practices are presented in the sections below. This is by no means an exhaustive list, but is intended to be used to help gain an understanding of some potential ways of reducing the environmental impact of development.

### 10.3.1 Reduce Limits of Clearing and Grading

The limits of clearing and grading refer to the area of the site that is disturbed during the construction phase, including area that is to be re-vegetated or even restored to a preferable environmental condition, but is disturbed during construction. To reduce the change in land cover and minimize hydrologic impact to the existing site, the development area should be located where impact on the runoff rate is lowest (e.g., on barren C and D type soils, which produce more runoff naturally than forested A and B type soils). At a minimum, placing the development area outside of stream and lake buffer areas or increasing these buffer areas will lead to a reduction in land cover changes. Some waterbody buffers are required, but increasing them can reduce the overall pollutant load that is required to be trapped.

### 10.3.2 Site Fingerprinting

Site fingerprinting refers to a number of minimal disturbance techniques which can be used to further reduce the limits of clearing and grading. Site fingerprinting identifies the smallest possible site area that must be disturbed and clearly delineates this on the site. This is important because even areas of a site not used for construction can be adversely impacted by construction equipment or materials compacting the soil, compromising vegetation, and leaving behind other pollutants like oil and grease. Techniques that can be used to minimize disturbance and preserve pre-development land cover include the following:

- Minimizing the size of construction easements, materials storage areas, and stockpiles within the development envelope as much as possible while still allowing enough room to build the structures and move equipment. Significant compaction can be caused by construction traffic and is the leading cause of death or decline of mature trees in developed areas (Hinman, 2005).
- Careful siting of lots and home layout, clearing and grading to avoid steep slopes, avoiding the removal of existing trees and excessive grading.
- If steep slopes cannot be avoided, use of mitigation practices such as bioretention cells or infiltration trenches should be implemented to attenuate the flow.

- Roof rainwater harvesting is particularly helpful to achieving LID goals in high density projects located on soils with low infiltration capacity.
- Minimize imperviousness by reducing paved surfaces on private areas. Examples are shared driveways, permeable pavements, or driveways with just wheel strips.
- Design homes on crawl spaces or basements that conform to natural grades without creating a flattened pad for slab construction. This also saves on clearing and grading costs.
- Flag the smallest site disturbance area possible to minimize soil compaction on site. Install construction fencing and tree protection where necessary to protect root structures along the limits of encroachment during the construction phase.
- Re-vegetate cleared and graded areas to provide an effective way to decrease post-development runoff. When minimal disturbance techniques are impossible or impractical, re-vegetation can be used to connect bioretention facilities to natural drainage ways, increase soil permeability, and mitigate land cover changes caused by development.

### 10.3.3 Preserve Permeable Soils and Vegetated Areas

The preservation of existing soils should be promoted in all unpaved areas throughout the site. Areas with well drained soils are generally good sites for bioretention cells and other BMPs and help sustain groundwater recharge and stream base flows.

Preservation of woodland areas can help reduce impacts on existing land cover. Woodland areas promote infiltration, distribute flow, reduce velocities, provide wildlife habitat, and help maintain streambank and bed stability. Saving existing trees on a development site is a cost-effective and quality-enhancing practice. Expansion of vegetated areas adds to the benefits of preservation by further reducing runoff volume. Trees and other native species should be kept in groups large enough to maintain soil moisture, sunlight, wind and other growth characteristics. Retaining mature trees of a single species is seldom successful (Hinman, 2005). For best results, flag tree preservation area at least 3-ft outside of the existing edge of canopy.

### 10.3.4 Alternative Roadway Designs

Roadways, sidewalks, driveways, and parking areas are the greatest contributors to increasing runoff and the size of the required detention/ retention structure. Impervious areas and the associated land clearing increase both the amount and rate of runoff over pre-development conditions. LID designs minimize the effective imperviousness of roadways and parking areas by using minimal grading and clearing techniques, minimizing impervious areas, and using open drainage sections. The following features can be incorporated into a roadway design to minimize land cover impacts while still meeting all of the County's Street Design Standards, found in Article 5 of the Land Disturbance Regulations (LDR). The Land Disturbance Regulations should also be consulted for restrictions on plant type, height, and location in stormwater structures located in ROWs.

- <u>Narrow road sections</u>: Small sections reduce impervious area and clearing and grading impacts. Reducing pavement widths from 26' to 20' reduces pavement area by 30%. A 40'-radius cul-de-sac with an interior bioretention area 15' in radius decreases impervious area by 707 $ft^2$ compared to a standard 40' cul-de-sac, while still allowing adequate room for emergency vehicles to turn around. Traffic calming techniques can also be used to minimize pavements while maintaining safety (refer to Article 8 of the LDR). Porous pavers may also be used where appropriate. Using queuing streets or porous pavers in peak overflow areas can reduce the size of parking lots.
- <u>Open Drainage Sections</u>: Grassed swales and infiltration trenches can be used in place of curb and gutter where allowed to distribute and attenuate the flow as well as enhance water quality and result in reduction of drainage pipes and associated infrastructure. With enough space, open

drainage sections can also incorporate bioretention to further enhance pollutant removal and flow attenuation.

- Road Layouts: Local and collector streets with curves and alignment changes allow the roadway to fit into existing topography, minimizing earthwork and hydrologic impacts. Curvilinear road layouts must meet current AASHTO and County LDR design requirements. Looped road layouts provide open areas in the center for bioretention as well as a visual break for houses facing the street. Minimizing frontage widths and providing green streets or open space pathways between homes for walking and biking will also reduce impervious areas.

## 10.3.5 Design of Roadways on Steep Slopes

LID designs generally avoid construction on steep slopes. However, in mountainous or hilly areas, this situation cannot be avoided, especially in the case of roadway drainage. Roads on steep slopes most often consist of a series of switchbacks cut into the hillside. These roadways typically have no crown and drain towards the hillside into a ditch or open conveyance. In curves or other areas a pipe or culvert will convey runoff from the ditch under the road and down the hillside. In order to provide adequate stormwater treatment and lower the impact for these roadways, a number of practices have been developed or adapted from existing practice.

One such practice is the addition of a filtration area beneath the open ditch with an under-drain to provide treatment of some of the runoff (by filtration). Designed in a similar manner to a traditional infiltration trench, a steep slope trench must account for much faster velocities due to the increased slope (up to 15%). This may require the bottom of the trench to be rip-rap, concrete or another material with high erosion resistance. In order to provide filtration with the use of concrete or rip-rap channel liners, the under-drain may have standpipes capped with grates every few hundred feet or as needed. Periodic outlet pipes should be installed to pass underneath the roadway to an outlet sufficiently protected from erosion. The object of the rock media is not to infiltrate water into the hillside soils, as this can reduce the stability of the slope and increase the risk of landslides; instead, it is to provide filtration and detention while conveying the runoff to an appropriate outlet point.

On the down slope side of the roadway, practices such as relief drains can be used to capture and convey water to an appropriate outlet. These drains also intercept groundwater seepage in the slope increasing slope stability, as shown in the example Figure 10-1 below.

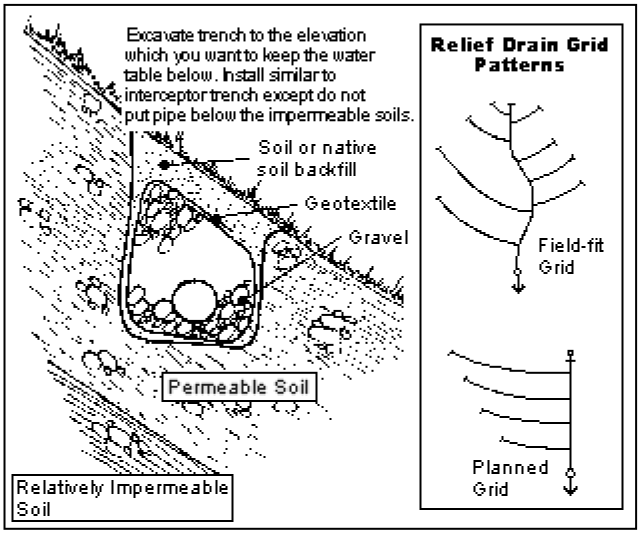


**Figure 10-1: Relief Drain Example from Washington Dept. of Ecology**

Other down slope practices are staggered crescent benches, which are staggered pockets to hold plantings, and chimney drains, which are vertical drains through the hill which have an outlet at the toe of the slope. A number of geosynthetics are also available. If retaining walls are present, weep gardens may also be appropriate.

### 10.3.6 Retention Storage

After following careful site planning guidelines and implementing practices to minimize changes in runoff volume, there will most likely still be a need for additional retention storage to emulate the predevelopment runoff conditions. When possible, smaller practices located closer to the sources of runoff than a traditional single-BMP approach are preferred. These practices are often incorporated as landscaped features, and can help provide more area for infiltration. Incorporating these distributed practices will not only help a site more closely mimic predevelopment conditions, it will reduce the size of any major retention structures for water quality and peak flow control.

### 10.3.7 Considerations for Residential Sites

Residential lots must be laid out to distribute retention storage volume as much as possible throughout the site. It is important to allocate enough area to provide for needed stormwater retention storage. In rare cases, adequate storage may be provided on each lot, but most often retention storage will be located in common areas. Due to maintenance concerns with individual homeowner-owned BMP structures, locating structural BMPs in common areas dispersed throughout the site is recommended. However, guidelines for locating certain types of on-lot retention storage areas on residential LID sites include the following:

- Locate swales and bioretention BMPs (rain gardens) where they can provide a green space connection to existing wooded or natural areas.
- Conflicts with underground utilities must be avoided.
- Infiltration or enhanced swales may be used in public rights-of-way.
- Keep all stormwater BMPs outside sensitive areas and undisturbed buffers.
- Ensure that the contributing drainage area to the site is stabilized prior to bringing any post-construction BMPs online.

### 10.3.8 Considerations for Commercial and Industrial Sites

For commercial or industrial sites, retention storage planning is focused on two areas: (1) perimeter buffer areas and (2) green areas located within parking lots. On-site retention storage can be provided as interior bioretention, located within required landscape islands, or as cistern facilities. If the available green space in the parking area is insufficient, bioretention within the landscaped buffer area located on the perimeter of the site can be used. Existing minimum green space requirements, plus the size of perimeter buffers and parking requirements, will dictate the feasibility of providing all required storage within surface swales, terraces, or bioretention facilities.

## 10.4 Final Design

As engineering plans are finalized, the designers should consider how to maximize the impact of the green infrastructure that will be constructed. This can be done using the following practices:

- Provide clear details, material specifications, and instructions to contractors to ensure that practices are constructed precisely as designed. Use the County's specifications and details when available, and ensure that any special instructions are made clear. It is important that the instructions be readable and include graphics where necessary. For many green infrastructure components, proper installation is just as important as proper design.

- Signs are required for stream buffers and conserved areas (Specification WQ-11), but it is good practice to include signs wherever they may be helpful. Promoting an understanding of water quality practices by home or business owners, landscaping contractors, and the general public can increase the effectiveness and extend the life of treatment practices. Instructions to stay out of practices, instructions to contractors or homeowners for landscape care and maintenance requirements, and even a description of the practice's benefits can all be used to encourage stewardship of the practice.
- A permanent maintenance plan is required by the County, and the maintenance schedule and activities are listed in each BMP's specification. It is vital that the owner is aware of this plan and has the proper tools and knowledge to keep the BMPs effective through proper maintenance. The designer should provide an inspection schedule with specific inspection items, a maintenance schedule including mowing, weeding, or other plant care instructions, and plans to make the owner aware of the components of the BMP that may not be visible from the surface.

Incorporating the above suggestions and attempting to reduce the amount of impervious cover, maximize the effectiveness of the site layout for water quality, and provide adequate resources for proper construction and maintenance of the site's water quality practices are essential for reducing the impact of any development. Designers are encouraged to consult with County staff about the water quality requirements early in the process, to utilize new and innovative technology and findings where appropriate, and to design new development and redevelopment projects to mimic, as closely as possible, the site's native hydrologic characteristics.